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ORIGINAL ARTICLES.

I.—Note on a Mounted Skeleton of *Ophthalmosaurus icenicus*, Seeley.

By C. W. Andrews, D.Sc., F.R.S. (British Museum, Natural History).

(PLATE V.)

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ONE of the most important additions recently made to the Gallery of Fossil Reptilia at the Natural History Museum, is a mounted skeleton of the highly specialized Ichthyosaur known as *Ophthalmosaurus icenicus*, Seeley. This reptile presents many peculiarities, for the most part indicating a very high degree of adaptation for life in the open sea and for rapid movement through the water, probably sometimes at considerable depths. In fact, *Ophthalmosaurus* may be regarded as representing among the Reptilia the swiftly swimming toothed-whales among the Mammalia, and it is interesting to note that the similar mode of life in the two cases has produced in some respects similar modifications. Thus the front paddles are enlarged, the hind ones reduced; in whales the latter have disappeared altogether. Again, there was a large caudal fin, vertical in this case, and the head was elongated, the snout sharp, and the neck so short as to be practically non-existent. The enlargement of the fore-paddles is brought about by the presence of a very large pisiform bone, which together with the radius and ulna articulates with the humerus, thus forming a very broad base for the expanded terminal portion of the paddle. Another striking peculiarity is the great reduction of the dentition, the teeth in the adult being very small and confined to the front of the jaws. *Baptanodon*, an American form very closely allied to, if not identical with, *Ophthalmosaurus*, was for a long time regarded as toothless. This reduced dentition, so unlike what is usually found in members of the group, must indicate some considerable change in the nature of the food, but what this was is unknown.

This specimen has been mounted with great skill and neatness by Mr. L. T. Parsons, so that any portion can be removed for examination without much difficulty. It is made up almost entirely from portions of three individuals: the mandible and skull, except the occipital region belong to one (R. 3702); the occiput, the sclerotic rings, the vertebral column nearly to the bend of the tail, the ribs, shoulder-girdle with the fore-paddles, and the femora to a second (R. 3893); while the remainder of the caudal region was supplied by a third

(R. 4124). The pelvis and some ribs have been modelled from other specimens. All the material employed was collected with his usual skill and care by Mr. A. N. Leeds, F.G.S., from brick-pits in the Oxford Clay in the neighbourhood of Peterborough, whence he also obtained the fine skeletons of *Cryptocleidus* and *Peloneustes* exhibited in the same gallery.

As usual when a skeleton is mounted in this way, it gives a very different impression from that derived from the examination of the separate bones, or even from the crushed specimens by which the Ichthyosauria are usually represented. One of the most remarkable features is the manner in which the long anterior ribs, borne on the vertebræ behind the axis, are crowded back, so as to pass within the scapulæ. That this arrangement actually occurred is shown in some of the crushed Liassic specimens, especially in the remarkably well-preserved examples from Holzmaden. There were about fifty pairs of ribs in all. The caudal fin must have been very large, the deflected portion of the vertebral column running down in the ventral lobe consisting of about fifty vertebræ; it is possible that as mounted this terminal portion of the vertebral column is bent down a little too sharply, the angle between it and the rest of the backbone being rather more obtuse.

The length of the skeleton as mounted is 13 ft. 6 in. (412 cm.), of which the head occupies 3 ft. 2 in. (96·5 cm.).

II.—A Deep Bore at Seascale in Cumberland.

By Professor J. W. Gregory, F.R.S., M.I.M.M., D.Sc.

DURING the years 1906 to 1909 a bore was sunk at Seascale on the coast of Cumberland, 9 miles south-eastward from St. Bees, in the hope of reaching a continuation of the Coal-measures which, south of Whitehaven, end against the Trias. This bore reached the depth of 3,200 feet, and it was then still in the Red Sandstone Series, which it entered beneath 20 feet of drift. Owing to the kindness of Mr. Forster Brown, I received a copy of the bore section, and from Mr. Fleming Smith, of Cleator Moor, manager of Vivian's Boring and Exploration Company, Ltd., who carried out the boring, further information regarding the bore, two samples of the core, and a copy of the journal for the lowest 180 feet. As the bore record is of especial geological interest, I am indebted to Mr. Forster Brown for permission to publish it.

Section of Borehole at Seascale.

	Thickness. ft.	in.	*Depth.* ft.	in.
Surface	20	5	20	5
Sandstone	584	0	604	5
Red Shale	5	0	609	5
Sandstone	1,463	6	2,072	11
Red Shale joints	3	0	2,075	11
Sandstone	37	0	2,112	11
Red Shale joints	2	0	2,114	11
Sandstone	13	6	2,128	5
Red Shale partings	4	0	2,132	5
Sandstone	6	0	2,138	5
Red Shale joints	6	0	2,144	5

	Thickness.		*Depth.*	
	ft.	*in.*	*ft.*	*in.*
Sandstone	3	6	2,147	11
Red Shale partings	9	0	2,156	11
Sandstone	94	0	2,250	11
Red Shale	2	0	2,252	11
Sandstone	53	0	2,305	11
Red Shale partings	12	0	2,317	11
Sandstone	23	0	2,340	11
Red Shale joints	9	0	2,349	11
Sandstone	23	0	2,372	11
Red Shale	45	6	2,418	5
Sandstone	20	0	2,438	5
Red Shale partings	6	6	2,444	11
Sandstone	7	6	2,452	5
Red Shale partings	8	0	2,460	5
Sandstone	81	6	2,541	11
Red Shale joints	5	6	2,547	5
Sandstone	148	0	2,695	5
Red Shale partings	9	6	2,704	1
Sandstone	53	6	2,758	5
Red Shale joints	6	0	2,764	5
Sandstone	63	0	2,827	5
Red Shale partings	7	6	2,834	11
Sandstone	72	6	2,907	5
Red Shale joints	1	6	2,908	11
Sandstone	56	0	2,964	11
Red Shale joints	1	0	2,965	11
Sandstone	9	6	2,975	5
Red Shale partings	5	6	2,980	11
Sandstone	8	0	2,988	11
Red Shale partings	6	6	2,995	5
Sandstone	24	0	3,019	5
Red Shale partings	3	0	3,022	5
Sandstone	177	7	3,200	0

Mr. Fleming Smith has sent me the following copy of the section book for the lowest part of the bore :—

	ft.	*in.*	*ft.*	*in.*
			3,022	5
Red Sandstone	16	1	3,038	6
,, ,, spar joints	1	7	3,040	1
,, ,,	8	11	3,049	0
,, ,, spar joints	4	7	3,053	7
,, ,,	10	9	3,064	4
,, ,, spar joints and shale partings	8	3	3,072	7
,, ,,	5	0	3,077	7
,, ,, spar joints	4	2	3,081	9
,, ,,	4	7	3,086	4
,, ,, shale joint	3	5	3,089	9
,, ,,	63	3	3,153	0
,, ,, spar veins	9	1	3,162	1
,, ,,	27	1	3,189	2
,, ,, shale joints	3	7	3,192	9
,, ,,	7	3	3,200	0

The general interpretation of this bore section appears to have been that all the rocks it traversed belong to the St. Bees Sandstone. This view seemed natural, since the band of rocks on which Seascale is situated appears to be the continuation of the sandstones of

St. Bees Head. That the whole of the 3,180 feet of strata belongs to the St. Bees Sandstone is, however, doubtful. One of the most characteristic features of the St. Bees Sandstone is its alternation of posts of red sandstone with beds of shale. Between the depths of 2,072 to 3,200 feet the rocks passed through in the Seascale bore have this character, for they consist of twenty beds of shale and shale partings and twenty beds of sandstone. Two core samples, which I owe to the kindness of Mr. Fleming Smith, one from the top and the other from the bottom of this lower part of the section, are both similar to the St. Bees Sandstone. The upper sample is a typical St. Bees Sandstone with partings of abundant white mica. The precise depth of this sample is not known. Mr. Fleming Smith tells me that it came from between the depths of 1,940 and 2,344 feet; and out of this 404 feet the top 132 feet lies within the thick upper sandstone, and the lower 272 feet belongs to the alternate sandstone-shale series. Judging from the aspect of the rock it probably came from one of the sandstones of the lower 272 feet belonging to the sandstone-shale series.

The specimen from the depth of 3,200 feet I examined microscopically on the chance of recognizing some material which would indicate the source of the constituents. It is a felspathic grit, similar to much St. Bees Sandstone; the section contains numerous rounded grains which have probably been derived from the Penrith Sandstone. As the section shows tourmaline and kyanite, Mr. G. W. Tyrrell kindly extracted some of the heavy residue; he has identified in it abundant zircon, tourmaline, magnetite, and ilmenite, many grains of andalusite, some of which are well rounded, and also particles of staurolite, kyanite, and possibly of cordierite and anatase.

In its microscopic characters the rock agrees with the St. Bees Sandstone; and this list of accessory constituents suggests that the material was derived from south-western Scotland rather than from the Lake District. The rocks on the margin of the Galloway Granite would have supplied the accessory minerals.

Further doubt as to whether all the beds belong to the St. Bees Sandstone is suggested by their great thickness. Goodchild, in one of the latest summaries of the geology of Cumberland, estimated the maximum thickness of the St. Bees Sandstone as 1,800 feet ("Geology" in *The Victoria History of the County of Cumberland*, vol. i, p. 36, 1901); and though it is possible that the formation may have suddenly increased to 3,200 feet, as by the filling up of an ancient valley, any such thickness of the St. Bees Sandstone was not expected when the bore was undertaken, and it justifies doubt as to the identification.

That the upper part of the Seascale bore was not in the St. Bees Sandstone is suggested by the great thickness of continuous sandstone, which, according to the bore record, amounts to 2,047 feet of sandstone interrupted by only a 5 foot seam of red shale. I know of no such occurrence in the St. Bees Sandstone. It is unfortunate that no cores from this upper Seascale Sandstone are available. Mr. Fleming Smith tells me that the cores have been dispersed, and if any specimens could be found there would be no evidence as to their depth. The only evidence available from the bore is the record of

the great thickness of this upper sandstone. The reference of 2,047 feet of sandstone, with only one 5 foot band of shale, to the St. Bees Sandstones is at least doubtful; and the possibility that this upper Seascale Sandstone may belong to the Keuper and represent the Kirklinton Sandstone must be considered. The Triassic beds beneath the drifts of Walney Island, 17 miles along the coast south-eastward from Seascale, have been transferred from the horizon of the St. Bees Sandstone to the Keuper.[1] The Keuper appears to be represented along the southern coast of Cumberland by its lower sandstones at Seascale and by its upper marls at Walney Island. If this suggestion be correct, the Keuper Sandstones are much thicker at Seascale than near Carlisle; but such an increase may be reasonably expected approaching the basin that no doubt existed to the west of Cumberland.

The Kirklinton Sandstone is very different in character from the St. Bees Sandstone; and if samples of the upper sandstone from the bore could be found the question could probably be at once settled; and if this note lead to the recovery of any sample of the core from the thick upper sandstone its publication will be well repaid.

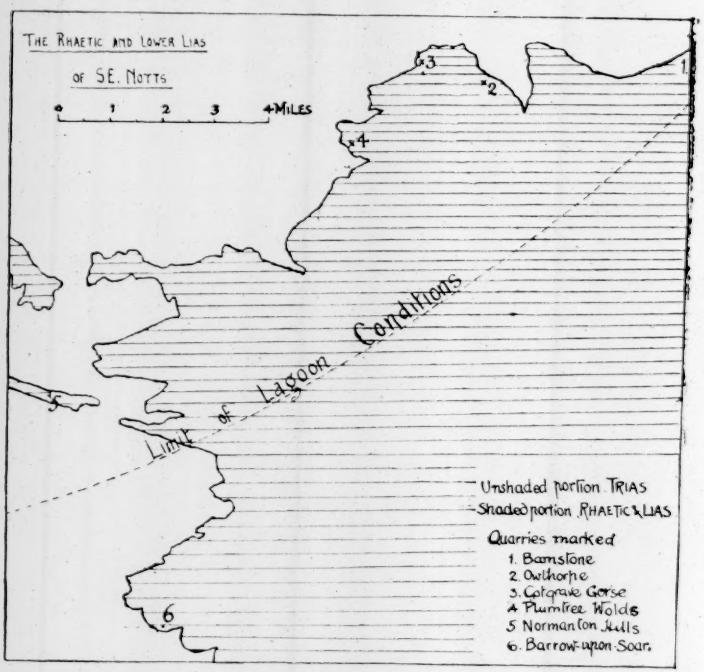
Fortunately, beside the beach at Seascale there is a scar of red sandstone, which is doubtless an outcrop of the upper sandstone of the bores. I owe to the kindness of Mr. Brockelbank, the station-master of Seascale, a collection of specimens from this exposure. The commonest rock is a red friable stone which crumbles readily beneath the fingers, and is a sandrock rather than a sandstone. Some of the specimens are more compact, and are entitled to be regarded as sandstone. In some the material has been cemented by a siliceous cement. Most of the rock is red, but some of it is white or greyish in colour. All the specimens are crowded with wind-rounded grains of quartz, and they have fewer grains of felspar. The specimens received show no layers of white mica. There are many specks stained dark brown by peroxide of manganese; and in two of the specimens some of the quartz grains have regrown into crystalline forms. These characteristics are not those of the St. Bees Sandstone; they occur in both Penrith Sandstone and Kirklinton Sandstone, some hand specimens of which are indistinguishable. The presence of the Penrith Sandstone at this locality is so improbable that of these two formations the Seascale beds would certainly belong to the Kirklinton Sandstone. Microscopic sections cut from three varieties of the rocks from the scar at Seascale show that they are strikingly different from the St. Bees Sandstone, and agree in all essential characters with the Kirklinton Sandstone. This outcrop therefore supports the inference from the bore record that the upper thick sandstone below Seascale belongs to the Keuper, and may be correlated with the Kirklinton Sandstone. The great thickness of the Red Sandstone Series at Seascale is therefore less surprising than if the bore had been begun in the St. Bees Sandstone.

[1] Geol. Surv. England and Wales. Map 4 miles to 1 inch. Sheets 5, 6, 1907.

III.—The Fauna of the Hydraulic Limestones in South Notts.

By A. E. Trueman, B.Sc., University College, Nottingham.

ALTHOUGH numerous papers, principally by the late E. Wilson,[1] describing the beds of the Rhætic and the Lower Lias of Notts, were published while exposures existed along railway cuttings in the south-east of the county, no account of the precise positions of important fossils is to be found. These exposures are now all grass-grown, but the junction of Rhætic and Lias may be seen in a number of quarries where hydraulic limestone is worked, either for cement or for road material. One of the best is at Owthorpe. Those at Cotgrave Gorse,[2] Barnstone,[3] Plumtree Wolds, and Normanton Hills[4] are confirmatory. The layers rich in Foraminifera have been of value in correlating these sections.



Constructed from the Index Map of the Geological Survey, No. 11.

The section at Owthorpe (300 yards S.S.W. of the Lime Kiln Inn) shows the following succession (the names given in brackets are the workmen's terms):—

[1] Q.J.G.S., vol. xxxviii, p. 454.
[2] *Geology of Melton Mowbray and South-East Notts* (Mem. Geol. Surv.), p. 19.
[3] *Jurassic Rocks of Britain*, vol. iii, p. 172.
[4] *Geology of Melton Mowbray and South-East Notts*, pp. 17, 18.

		ft.	in.	
Beds with *Planorbis*.	Yellow calcareous clay	1	0	Worn Saurian vertebræ, *Lima*.
	Pale flaggy limestone (Skerries)		10	*Psiloceras planorbis*, *Amm. Johnstoni*.
	Coarse clay		3	Echinoid spines, Ostracods, fish-scales, *Lima*, Belemnites.
	Yellow earthy nodular limestone with 'spine-bed' at top		6	*Ps. planorbis*, *Ostrea*, *Lima*, *Modiola minima*, *Turbo* sp.
	Dark calcareous shale		2	Spines, Fish-teeth, Foraminifera.
	Blue-hearted earthy limestone		2	*Ps. planorbis*, *M. minima*.
	Shale		9	Spines, Ostracods, fish-teeth, Foraminifera.
Beds without *Planorbis*.	Dark, blue-hearted limestone		3½	*Pecten* sp., *Lima*, *M. minima*.
	Shale (Twins)		2	Spines, Ostracods, many Foraminifera (*Nodosaria*).
	Limestone as above		3	*M. minima*.
	Shale	2	0	Foraminifera, spines, Ostracods.
	Blue, wavy-banded, fine-grained limestones, with shell bands near top	2	0	*Ostrea irregularis*, *O. liassica*, *Pleuromya crowcombei*, *Avicula cygnipes*, *M. minima*, spines.
	Fine-grained, well-laminated, blue calcareous mudstones	1	3	*M. minima* and Ostracods, rare; worm bores.
	Fine dark-blue limestone		5	*M. minima*, rare.
	Mudstones, as above		2	Ostracods, rare.
	Variable limestone bands		3	*Ostrea*, rare; *M. minima*.
	Mudstones, as above	2	0	*M. minima*.

Soft blue clay, Rhætic, below level of working.

Similar beds without *Planorbis* are described as "pre-*Planorbis* beds" by L. Richardson in the neighbourhood of Cheltenham.[1]

A comparison of the above section with that at Barrow-upon-Soar (in North Leicestershire, 11 miles distant) is instructive. While in the section just described about 8 feet of beds occur between the Upper Rhætic and the lowest beds with the zone fossil, there *Psil. planorbis* occurs also in beds which immediately succeed the Upper Rhætic.

As shown by the following table, the beds without *Planorbis* at Owthorpe (and also at the other exposures mentioned previously) are of Liassic age, for the fauna differs only slightly from that of the overlying beds with *Planorbis*.

	Upper Rhætic.	Beds without *Planorbis*.		Beds with *Planorbis*.
		Lower.	Upper.	
Ostrea liassica		r.	C.	c.
O. irregularis		r.	C.	c.
Lima gigantea		r.	c.	C.
Saurian remains			r.	C.
Pecten sp.			C.	C.
Foraminifera		r.	C.	C.
Echinoid spines		r.	c.	C.
Pleuromya crowcombei		r.	C.	
Avicula cygnipes			r.	
Estheria minuta	c.			
Modiola minima	r.	C.	C.	C.
Cytheridea sp.	r.	C.	c.	c.

r. rare; c. fairly common; C. very common.

[1] *Geology of Cheltenham*, pp. 21–36.

[2] *Geology of Melton Mowbray and South-East Notts*, p. 29.

Moreover, the fossils found at Barrow are on the whole the same, and show a similar distribution, so that the bottom beds at Owthorpe and Barrow must be homotaxial. This being the case, it is evident that the beds at Owthorpe can hardly be called "pre-*Planorbis*", for at the time of their deposition *Planorbis* was in existence a few miles away.

The character of the fauna in the lowest beds of all in the Owthorpe district suggests a possible explanation of the absence of *Planorbis*, for it is very impoverished, the only fossils being *Modiola minima* and Ostracods (*Cytheridea ellipsoidea*, Jones). This type of fauna is characteristic of lagoon phases, for, according to Mr. Dixon, these are "all distinguished in places by exceedingly fine-grained calcite mudstones with an impoverished fauna of Lamellibranchs (especially *Modiola*), Ostracods, and *Spirorbis*. A certain amount of terrigenous material, mud, and fine sand is found in them all".[1]

Confirmatory evidence of such conditions in the Owthorpe district is seen in occasional worm bores and traces of ripple-marks. Further, the occurrence of insect-remains at Barrow, indicating the proximity of land, supports rather than opposes this view.

With regard to the underlying Rhætic beds, it might be here recorded that the top bed of Rhætic limestone at Cotgrave Gorse is cracked, the cracks being filled with calcite. The upper edges of the blocks often show a pitted and bored appearance, which may in some cases have been caused by worms. A similar bed has been described near Bath, and is there called the Sun Bed.[2]

I should like to express my thanks to numerous friends who at various times have assisted me in the field, and to Professor H. H. Swinnerton, of University College, Nottingham, whose inspiration and help are mainly responsible for this little paper.

IV.—The Intrusive Rock of Marston Jabet, Nuneaton, Warwickshire.

By Alfred Brammall, B.Sc. (Lond.), F.G.S., Assistant Director of Education, Bury, Lancs.

(PLATE VI.)

1. *Introduction and References to Literature.*

THE intrusive rocks of Marston Jabet and Chilvers Coton, though probably of quite minor importance, have been rendered noteworthy by the variety of opinions held regarding their true position in a scheme of rock classification. This is especially the case as regards the rock quarried at Marston Jabet. Thus Allport[3] comments upon certain remarkable features distinguishing this rock, which, however, seems to be covered by his general statement that the intrusive rocks of the Warwickshire Coalfield are for the most part ordinary diorites. Rutley[4] concurs in the opinion expressed by

[1] Q.J.G.S., 1911, p. 571.
[2] *Geology of Wellington and Chard* (Mem. Geol. Surv.), pp. 27, 28.
[3] Q.J.G.S., vol. xxxv, p. 637, 1879.
[4] Geol. Mag., 1886, p. 562.

Allport. Watts[1] calls attention to the lamprophyric aspect of the rock, which he terms a camptonite; and with this description Harker[2] agrees. Hatch[3] admits the lamprophyric features and incidentally refers to the lack of recorded analyses.

The conclusions arrived at in this paper are based upon a detailed examination of the rock in situ, upon a microscopic investigation of a large number of thin sections, and upon a partial chemical analysis of the prevalent rock type.

2. *The Intrusive Character of the Marston Jabet Rock.*

There is no question as to the intrusive character of the rock; for completeness, however, the evidence for intrusion is set out below in some detail, the features described being those observed at the quarry in August and December, 1912.

The country rock is Coal-measure shale horizontally bedded. In the middle of the quarry is a horizontal platform of shale from above which igneous rock has been removed. At the quarry face the latter rock extends for several feet below the plane of the middle platform; it is therefore clearly transgressive.

At the north-east end the quarry face is a pillar of laminated shale continuous with the platform below and extending upwards to the ground level. The shale is injected with narrow veins and strings of 'white trap' along bedding- and joint-planes. The veins and strings are frequently transgressive, and may also be traced into the main mass of igneous rock.

To the east and south long slabs and smaller lenticular masses of shale are seen embedded in the igneous rock. In the southern face two constant horizons of igneous rock are separated by a shale band 2 feet thick; both the shales and the igneous rock sag slightly.

The shale bordering the tramway incline is baked a brick red for a distance of about 2 feet above the igneous rock. Shale at the contact is usually porcellanized for a distance of one inch, and indurated for a greater, though variable, distance beyond. *Lit-par-lit* injection of the shale is frequent. The texture of the igneous rock near its junction with the shales is compact and basaltic, whereas in the centre of the mass it is crystalline.

The rock is obviously a sill-like intrusion in the shale, which, however, appears to have suffered little or no disturbance.

3. *Macroscopical Features of the several varieties of the Intrusive Rock.*

The prevalent rock is greenish-grey crystalline, of fine or medium texture, having a distinctly dappled or mottled appearance when wet, owing to concentrations of hornblende and of felspar as minute but discrete clots—glomeroporphyritic structure, which is assumed by both hornblende and felspar. Pyrites in specks and irregular strings is very abundant.

The mottled variety passes insensibly into a more homogeneous, finely crystalline rock, with the aspect of the Nuneaton and Atherstone 'diorites'. Both the varieties noticed effervesce slightly on

[1] Proc. Geol. Assoc., vol. xv, pp. 394–96, 1897.
[2] *Petrology for Students*, 1908 ed., p. 157.
[3] *Text Book of Petrology*, 1909 ed., pp. 329–30.

treatment with dilute hydrochloric acid, owing to the presence of calcite in the rock-mass.

Another variety, occurring as a selvage in contact with the shale, is a dark-grey compact rock, often banded, but otherwise of basaltic aspect, though no crystals are visible even on examination with the lens. The material forming the veins and strings intrusive in the shales is an earthy substance with the appearance, texture, and 'feel' of hardening putty.

4. *Detailed Petrological Description.*

The felspar is mainly plagioclase, which forms slender idiomorphic prisms up to $\frac{1}{10}$ inch in length, usually less, showing between crossed nicols broad but inconstant twin laminæ of the albite type, occasionally combined with Carlsbad and pericline twinning; an extinction angle of 27°–29° points to labradorite of basic composition. The well-individualized albite laminæ of the middle of the felspar prisms are commonly flanked by a narrow marginal band, the extinction axis of which appears to traverse the band from side to side as the stage is rotated—an optical feature due to zonal variation in chemical composition. Orthoclase is a very subordinate constituent of a scanty granular ground-mass.

The felspar has a pronounced yellow-brown tint due to iron staining, and has undergone considerable alteration, resulting in the development of granular calcite and epidote, aggregated mainly in the interior. The alteration has only slightly obscured the definition of the albite laminæ—the contour of the crystal not at all.

The prisms form an open framework, and are frequently interpenetrant at the nodes, where they tend to group themselves radially after the manner of the glomeroporphyritic aggregates common in intrusive and volcanic rocks. This framework, together with hornblende, calcite (in plates or granules), a little granular orthoclase, and rather conspicuous grains of magnetite, is embedded in a nearly colourless or pale-green serpentine associated with subordinate patches of a greenish dichroic substance referred to chlorite.

In the normal type of the rock the felspar prisms may be enclosed in hornblende; in some varieties the two minerals interlock along a sinuous or serrated line, a portion at least of the hornblende having been fluid at a stage when the crystallization of the felspar was incomplete. In yet another variety the hornblende is wholly idiomorphic and independent of the felspar.

Hornblende is very abundant as a dark-brown variety which, when unaltered, is quite transparent and shows intense brown absorption. Often, however, it is so dark as to be almost opaque, suggesting a somewhat advanced stage of alteration. The mineral is conspicuously idiomorphic, giving the usual lozenge-shaped basal sections (acute angles truncated by the clinopinacoid traces) and long prismatic sections. Twinning on the orthopinacoid is common. Hornblende may enclose plagioclase prisms ophitically, or may be conjugate with felspar along a straight, curved, or serrated junction line, or may be an entirely independent constituent. All stages of alteration to serpentine are observable; the serpentine either merely

pencils out the cleavages in basal and prismatic sections; or it occurs as coarse irregular ropes traversing the crystal plates in directions roughly parallel to the cleavages; or the original hornblende has been reduced to a meagre skeletal framework embedded in serpentine.

As the opaque brown masses, hornblendic in colour, were suspected to be, in part at least, limonitic, the cover glass of a section was removed, the section cleansed of balsam, and a drop of strong hydrochloric acid applied to the brown mass. In a very few seconds the drop had become coloured a distinct yellow, as shown on its absorption by white blotting-paper, thus proving the presence of iron in some very soluble form in the brown mass, which was therefore composed partly of limonitic matter.

The abundant development of calcite plates in close association with serpentine and limonite suggests its derivation from hornblende rich in lime as well as magnesia, and therefore of the 'basaltic' variety. Relics retaining parallel cleavage traces in single system (i.e. sections more or less nearly in the prism zone) give nearly straight extinction with reference to the cleavage traces. (Pleochroism: a = straw or pale yellow; β or γ = light brown or dark brown.) Narrow strips of a transparent substance, with recognizable cleavage traces, very pale yellow in ordinary transmitted light, and showing intense brown absorption in plane polarized light, appear to be unaltered portions of original hornblende which has suffered bleaching.

The decomposition of the hornblende appears to have proceeded in two different ways—either (*a*) the whole mineral has altered by hydration to serpentine; this is the prevalent method; or (*b*) the magnesia alone has separated from the hornblendic molecule to form serpentine; the lime has formed calcite (as plates and granules) or epidote (as granules), the residual iron as the hydrated oxide retaining the form of hornblende.

In support of the latter suggestion it may be stated that the serpentine contiguous with opaque hornblende relics is usually only very pale green owing to its low iron content, whereas the colour of the serpentine which has originated by method (*a*) is always a pronounced green or yellow-green.

The proportion of serpentine is fairly constant, even when definite indications of original olivine are absent; moreover, it shows a characteristic fibrous or 'bladed' structure under crossed nicols; the major portion, at any rate, of the serpentine may be referred with confidence to hornblende.

The murky-grey colour and complete opacity of much of the limonite suggest admixture with leucoxene representing the titanium of the original hornblende molecule. Some leucoxene is certainly derived from the alteration of titaniferous magnetite.

Rounded or elliptical patches of serpentine showing the 'mesh' structure under crossed nicols occur embedded in the hornblende relics, or very rarely in the felspar; they appear to represent original olivine, very subordinate in quantity. Olivine is probably also represented in the serpentine of the base. The quantity of olivine present is somewhat variable and always small.

Magnetite is abundant in some sections, and present in all. It is titaniferous, as indicated by a greyish opaque outgrowth of leucoxene.

In more than a score of sections examined no augite or other pyroxenic material was observed. Mica is wholly wanting. Apatite is conspicuous as needles, from ·025 mm. to ·075 mm. in length, embedded in the other constituents. Pyrites in granules up to ·3 mm. in length is also a notable accessory.

5. Discussion of the Systematic Position of the several Varieties.

Typically the felspar and hornblende show a marked tendency to idiomorphism. The low degree of mutual interference shown by the felspar prisms in particular, the almost total absence of the 'granitic', and the prevalence of the 'glomeroporphyritic' structure are incompatible with diorites. On the other hand, these features may be either hypabyssal or volcanic; the absence of a glassy base eliminates the latter as a probability, while the ophitic relationship of the felspars and hornblende, and the basic character of the former (labradorite), recall the structure of the typical dolerites, and the coming in of olivine suggests analogy with the olivine dolerite type. Dolerites, however, are typically pyroxenic, and in this rock pyroxenes appear to be wholly wanting, and no secondary amphibole, which might have been referred with reason to primary augite, was observed. The idiomorphism and the primary character of the hornblende are incompatible with the type dolerites.

On the other hand, individual femic clots may monopolize the whole of a field visible under the microscope; in such case the subordinate amount of the felspar visible, the serpentinous pseudomorphs of olivine, occurring as pœcilitic inclusions in the hornblende, recall the picrites; but even this resemblance is illusive, for the field adjoining such a femic patch may be entirely devoid of hornblende and even comparatively free from its serpentinous decomposition products. Moreover, the rock as a whole must be excluded from the picrite group by reason of the high proportion of felspar and the very small amount of olivine present.

The idiomorphism and porphyritic aspect of the hornblende, considered together with other hypabyssal features, admit the rock without question into the lamprophyre group. The red-brown hornblende, the essential absence of free silica, the conspicuous apatite and titanium content link the rock with the type camptonite of Campton Fells, N.H., and the classification of the main rock-mass as a camptonite is open to little objection. The olivine, too insignificant in quantity for the picrites, ranks as a noteworthy accessory when the rock is regarded as a camptonite. In the typical camptonite, however, hornblende recurs as microlites in the base. This is not the case in the Marston Jabet rock.

The camptonite rock forms the bulk of any one of the sheets of the intrusive mass. The olivine is more abundant in the centre of the mass than near the margin, and it is in the centre that the nearest approach to a picritic facies was observed.

A partial analysis of the mottled rock was carried out in the

laboratory of the Bury Technical School in consultation with Mr. G. M. Norman, B.Sc., F.I.C., A.R.C.S., and the results obtained, together with recorded analyses (cited by Hatch) of other camptonites and of a well-known picrite, are set out below:—

	Camptonite (Marston Jabet).	Camptonite (Ardmuchnish).	Camptonite (Orkneys).	Picrite (Blackburn–Bathgate Hills).
	%	%	%	%
SiO_2	44·75	42·22	39·13	44·73
Fe_2O_3	15·15	4·74	7·33	4·85
FeO	(estimated as Fe_2O_3)	6·18	8·13	6·61
Al_2O_3	16·26	10·62	11·38	11·89
MgO	11·72	8·68	8·64	10·77
CaO	7·35	14·80	11·77	7·69
Na_2O	not estimated	2·46	2·47	2·77
K_2O		1·41	1·93	·89
TiO_2		2·49	4·02	1·53
CO_2		3·57	2·41	—
H_2O		1·66	2·87	7·64
P_2O_5	0·22			
Other constituents		1·59	0·42	1·06
		100·42	100·50	100·43

The selvage rock, when examined in thin section, presents the ordinary features of an andesitic basalt and calls for no special description.

Very little absorption of the shale by the igneous rock has taken place at the junction, and the absorption zone is probably not more than $\frac{1}{8}$ in. wide. In sections showing the igneous rock and the shale in contact, the former near its junction with the latter is very dark, almost black, and quite opaque, due probably to the presence of free carbon derived from the shale, on the solution of a very limited amount of its alumina. The frequent occurrence of a pencil-like vein of calcite crystals marking the contact plane indicates that the latter became a plane of discontinuity after the intrusion, and, therefore, that the intrusion was accompanied by a negligible amount of chemical reaction between the igneous mass and the shales.

The earthy material forming the veins and strings which penetrate the shales recalls the 'white trap' (kaolinized basalt) described by Geikie[1] as penetrating Lower Carboniferous shales in the Lowlands of Scotland.

6. *The Alteration produced in the Shales.*

In the main the alteration is of the low grade and small extent usual for similar intrusions; but a microscopic investigation of certain portions of these shales in thin section reveals the presence

[1] Q.J.G.S., 1892, Pres. Address, p. 136.

of embryonic crystals, the features of which so closely approach those of chiastolite as to render the identity highly probable. This 'unconventional' occurrence of chiastolite will be fully discussed in the May Number of the GEOLOGICAL MAGAZINE.

EXPLANATION OF PLATE VI.

STRUCTURAL TYPES.

FIG. 1.—A dioritic facies—but with pronounced hypabyssal features. Hornblende relics, of somewhat raggy outline, but tending to idiomorphism; cleavages pencilled out in serpentine. Base made up of much altered plagioclase as prisms and irregular plates, the clear interspaces being filled with chloritic and serpentinous matter; some calcite; abundant apatite; some titaniferous iron-ore (with leucoxene); grains of pyrites; and a little granular epidote in plagioclase, of which it is a decomposition product.

FIG. 2.—A picritic facies. The proportion of plagioclase is much lower than for No. 1; it occurs not only in the base but as minute prisms enclosed ophitically in hornblende. Clear patches represent crystals of original olivine now altered to serpentine, which also envelops plates and granules of calcite. Circular and elliptic 'lakes' of serpentinous matter enclosed pœcilitic fashion in the hornblende appear to represent original olivine.

FIG. 3.—A coarse lamprophyric facies (camptonite). The idiomorphic hornblende is, in the main, phenocrystal, though the presence of small felspar prisms as enclosures in the hornblende is (for lamprophyres) an anomalous feature. This ophitic relationship of the felspar to the hornblende recalls the structure of typical dolerites (the hornblende playing the rôle of pyroxene in dolerites); and it may be that the fluid intrusive, potentially doleritic, has crystallized at a temperature too low to promote the formation of pyroxene, i.e. at a temperature at which hornblende can form and remain stable; in this sense the camptonite may be an abortive dolerite. But the phenocrystal aspect of the hornblende (with other hypabyssal features) insistently recalls the lamprophyres: the rock must be regarded as a variety of camptonite.

FIG. 4.—A fine-grained hornblende lamprophyre (closely related to the coarse camptonitic facies), in which the idiomorphic hornblende occurs as minute laths.

V.—THE ORIGIN OF LIMESTONE.

By H. WARTH.

ALTHOUGH the calcium oxide and magnesia of sedimentary limestone and dolomite must all be derived from pre-existing igneous rocks, it is not so easy to trace the origin of the necessary carbon dioxide. The solidified igneous rocks contain mere traces of free carbon dioxide and of calcite. During their weathering carbon dioxide is taken up from the atmosphere, replacing the silica of calcium silicate and magnesium silicate minerals, and forming the carbonates. Now, however, the quantity of carbon dioxide retained in the atmosphere is exceedingly small. It is difficult to credit, for instance that a layer of coal, 1½ millimetres thick, covering the surface of the globe, on being burnt would yield as much carbon dioxide as the entire atmosphere now contains. A similar layer of limestone containing an equivalent amount of carbon dioxide would have a thickness of 5 millimetres. This is out of all proportion compared with the mighty beds of limestone and dolomite now forming part of the earth's crust. Nor would the carbon dioxide

A. Brammell, Photo. Bale, Sons and Danielsson, Ltd.

of the sea avail anything. It exceeds in quantity that of the air, but is still at the most equivalent to 7 centimetres of limestone covering the earth's surface. Now the existence of animal life throughout the sedimentary era implies that from the earliest times the composition of the earth's atmosphere cannot have differed very materially from the present one. Yet as carbon dioxide has been continuously taken up by weathering igneous rocks, and also by the production and storage of mineral, coal, etc., there must have been a continuous renewal of the carbon dioxide contents to maintain an equilibrium. The distribution of limestone throughout the whole sedimentary era, and the alternate occurrence of coal of different ages, leave no doubt that there has been a regular accession or renewal of carbon dioxide from first to last. The only question we have to answer is where this carbon dioxide was derived from.

The amount of carbon dioxide as calcite and in the free state in the solidified igneous rocks is far too little for the above purpose, but there is ample evidence of a continuous supply by exudation from deep-seated parts of the earth's crust. The gas issues either by itself at isolated points in smaller quantity, or else in larger bulk in certain volcanic regions. Much of it appears also in solution in mineral springs. The possibility of a continuous supply is demonstrated by the fact that fiery liquid lava is known to give up carbon dioxide on its appearance at the earth's surface. It is thus clear that the cooling and solidification of igneous rocks may be accompanied by an issue of carbon dioxide gas, and this issue will be very regular, as the process of cooling is also regular and practically constant. This, then, is the source from which the atmosphere is supplied with carbon dioxide, which is all the time utilized in the production of limestone and dolomite, coal, bitumen, etc.

To confirm this explanation it would be necessary to collect statistics, firstly of all the stores of limestone on the earth's surface, and secondly of the approximate issue of carbon dioxide. It would be no small task to procure such data with any degree of accuracy. Meanwhile a very rough estimate might be made, or should we call it a guess, to serve the purpose of a test. If we assume the accumulated sedimentary limestone of the earth's outer crust to equal a bed 50 metres in thickness covering the land surface of the globe, and if we fix the duration of sedimentaries containing organic remains (animal) at fifty million years, we can easily calculate the uniform issue of carbon-dioxide gas per second. This uniform issue of gas equals at 760 millimetres pressure 2,500 cubic metres.[1] Considering the size of the earth we may rest satisfied that this amount is at all events of the right order of magnitude, and that the above hypothesis stands on a good foundation. We have thus before us one more of the wonderful provisions for the persistent development and maintenance of plant and of animal life on the globe.

[1] I find records in Bishop's *Elements of Chemical and Physical Geology* showing that the mineral springs at Cannstatt yield one quarter of a cubic metre of carbon dioxide per second.

VI.—The Principle of Saturation.

By Alexander Scott, M.A., B.Sc.

IN Professor Shand's reply [1] to my criticism [2] of his original paper [3] on the application of the principle of saturation with respect to silica in the classification of igneous rocks, some points arise which make it clear that he has misunderstood me in several particulars. In the beginning of my paper, it was explicitly stated that what was to be considered was (1) whether the principle, as enunciated by Professor Shand, could be extended to minerals other than the silica ones (quartz, tridymite, etc.), the felspars and the felspathoids, and (2) whether the criterion whereby the rock minerals were divided into the two groups of saturated and unsaturated was sufficiently exact. The criterion used was that of "the observed facts of distribution", and any mineral which was found coexisting with quartz or some other form of silica in igneous rocks was said to be saturated, while those which did not occur along with quartz were said to be unsaturated. Correspondingly, rocks which consisted entirely of minerals of the former type were classed as saturated, those consisting of mixtures of the two types as part-saturated, and those consisting solely of the second type as unsaturated. I endeavoured to show that the rock-forming minerals cannot be satisfactorily divided into two classes in this empirical fashion, without any consideration of the cooling-histories of the individual rocks in which the minerals may be found.

One of the specific points discussed was the possibility of the coexistence of quartz and olivine in an igneous rock, and I indicated two ways in which free silica (other than xenolithic) might exist *in small quantities* in a part-saturated or unsaturated rock. What was suggested was, that under certain particular conditions metasilicates might dissociate into orthosilicates and free silica; while, under other conditions, silica might be set free by the hydrolytic action of water. No attempt was made to suggest that the coexistence of the two minerals was general or that the circumstances favouring it were other than exceptional, and hence the instances of the Kilsyth–Croy sill,[4] Garabal Hill,[5] etc., are not relevant to the point at issue. The work of Anderson and Bowen[6] was quoted merely as a verification of the idea that dissociation was possible. These authors, however, have pointed out that this dissociation, despite the fact that it takes place above 1557°, has a distinct petrological bearing. Again, olivine is seldom the pure magnesium orthosilicate, but generally contains a considerable amount of the corresponding ferrous salt. If, as is probable, the latter also undergoes dissociation near its melting-point, silica will be set free at temperatures much below 1557° and well

[1] Geol. Mag., Dec. V, Vol. X, pp. 508–14, 1913.
[2] Ibid., Dec. VI, Vol. I, pp. 319–24, 1914.
[3] Ibid., Dec. VI, Vol. I, pp. 485–93, 1914.
[4] Geol. Mag., Dec. V, Vol. VI, pp. 299–309, 1909.
[5] Ibid., Dec. V, Vol. X, pp. 499–508, 1913.
[6] *Amer. Journ. Sci.* (4), xxxvii, pp. 487–500, 1914; *Zeit. für Anorg. Chem.*, lxxxvii, pp. 283–99, 1914.

below the temperatures of crystallization of many igneous rocks, since the melting-point of fayalite is given by Vogt[1] as 1065°, and fayalite and forsterite form a continuous series of solid solutions conforming to Roozeboom's Type I.[2]

There is a very considerable amount of evidence against Professor Shand's view that the compound $Fe\,Si\,O_3$ cannot exist under any conditions realized in nature. Thus an amphibole, grünerite, consisting of almost pure $Fe\,Si\,O_3$, has been described from Collobrières in France.[3] Hypersthene consists of an isomorphous mixture of $Mg\,Si\,O_3$ and $Fe\,Si\,O_3$, as the two salts form a series similar to the corresponding orthosilicates,[4] and hence both must exist in a free state. The occurrence of $Fe\,Si\,O_3$ in the double salt hedenbergite, $Ca\,Fe\,Si_2O_6$, also points to its free existence, in the liquid condition at least. The rarity of crystals of pure $Fe\,Si\,O_3$ is probably to be explained by the fact that rocks with Fe O generally contain Mg O as well, and by the tendency of $Fe\,Si\,O_3$ to form double salts and to enter into solid solution not only with enstatite but also with monoclinic pyroxenes. The occurrence of fayalite in the lavas of Pantellaria[5] is best explained by the dissociation hypothesis, the unstable form persisting as the result of the undercooling to which these rocks would be liable owing to the rapid fall in temperature on extrusion.

With respect to the felspathoids, the remarks in my paper regarding the reaction

$$\text{kaliophilite} + \text{orthoclase} \rightleftharpoons \text{leucite}$$

referred to crystallization from the liquid state, and no mention was made of the transformation, in the solid state, of leucite to pseudo-leucite. What was stated was that a rock, which under some conditions might crystallize as a leucite rock, would under other conditions form a nephelite-felspar rock. That this case is very pertinent to the question at issue, is shown by the following example. A leucitite or leucite-basalt, in which the predominant minerals are leucite and olivine, would have to be classed as unsaturated. A rock of the same chemical composition could also solidify as a nephelite-felspar-olivine rock, which would be classed as part-saturated. The two rocks would therefore be widely separated in classification, although, petrologically, they would have many affinities, and would exhibit the same tendency to react with any sediments with which they were in contact. The same anomalies appear when analcite is considered in place of leucite.

The chief point in objecting to the garnets being classed partly as saturated and partly as unsaturated is their probable origin under particular conditions of temperature and, more especially, pressure. The fact that most garnets break up on fusion and recrystallize as mixture of other minerals is in favour of this, as is

[1] *Die Silikatschmelzlösungen*, ii, p. 66, 1904.
[2] Ibid. i, p. 152, 1903.
[3] *Comptes Rendus*, xxiv, p. 784, 1847; Bull. Soc. Min. Franç., ix, p. 40, 1886.
[4] Vogt, loc. cit., ii, p. 112.
[5] *Journ. Geol.*, xxii, pp. 16–27, 1914.

also their comparative restriction to metamorphic rocks. Shepherd and Rankin[1] found that grossularite broke up on melting to give a mixture of anorthite, pseudo-wollastonite, and gehlenite (?), and that it did not appear on the fusion surface of the ternary system $CaO - Al_2O_3 - SiO_2$. Of the three garnets which commonly occur in igneous rocks, pyrope is always a product of early separation from the magma, and its probable instability at lower temperatures and pressures is shown by the frequent occurrence of celyphite-borders. Thus Rosenbusch says[2]: "Er [Mhra] nimmt an, dass der in grösserer Tiefe gebildete Pyrop bei Abnahme des Druckes wahrend die Aufsteigens des Magmas mit dem Olivin in Reaktion trat." Its occurrence in a lava does not militate against its crystallization under plutonic conditions, as such rocks are generally considered to have two periods of crystallization, one 'intratelluric' and the other 'effusive', the formation of pyrope belonging to the former.

With regard to melanite, it seems that the chemical factor which determines its occurrence is not so much the amount of silica as the titanium-content, since rock-forming melanites are generally rich in the latter element. Thus, the garnet of the nephelite dolerite of Oberweisenthal contains 10·84 per cent of TiO_2.[3] Again, in the Borolan complex, melanite seldom occurs along with primary sphene, which, however, tends to increase as the melanite fails. The latter also alters readily to secondary sphene.[4] This fact points to the instability of melanite, and indicates that under other conditions a mixture of sphene and, probably, pyroxene, would have taken its place. Further, Weinschenk states that titanium free-lime garnet occurs exclusively as a secondary product of volcanic activity.[5] In some of the occurrences of spessartite it has been shown that the mineral is of pneumatolytic origin,[6] while in practically the only synthesis in which the composition was verified by analysis a mixture of hydrogen and steam was used as a catalyst.[7]

Similar objections can be raised to many other minerals being classed as saturated or unsaturated merely on the strength of their field occurrence. If the variability of composition in the amphibole group is an insuperable barrier to the correlation of mineralogical and chemical composition, it is likewise a barrier to the saturation classification. Numerous amphiboles and pyroxenes have been described containing an amount of silica insufficient to 'saturate' the bases present, and this has led to the postulation of such molecules as $R''Al_2SiO_6$, which can obviously take up more silica. Whether these hypothetical molecules actually exist or not, the fact remains that some of the minerals included in the pyroxene and amphibole groups are deficient in silica.

[1] *Journ. Ind. Eng. Chem.*, iii, No. 4, p. 10, 1911.
[2] *Mikroskopische Physiographie*, 4th ed., i, ii, p. 25, 1905.
[3] Rosenbusch, *Elemente der Gesteinlehre*, 3rd ed., 1910, p. 458.
[4] Shand, Trans. Edin. Geol. Soc., ix, pt. iii, p. 205, 1909; pt. v, p. 386, 1910.
[5] *Zeit. Kryst. Min.*, xxv, p. 375, 1895.
[6] Penfield & Foote, *Amer. Journ. Sci.* (4), iv, p. 105, 1897.
[7] Gorgeu, *Ann. chim. phys.* (4), iv, pp. 515–56, 1883; *Compt. Rend.*, xcvi, p. 1303, 1883.

While so many obvious difficulties stand in the way of the determination of the degree of saturation of the rock-minerals, there are fully as many when the rocks themselves are considered. The method, in common with all purely mineralogical methods, fails when, not only vitreous, but all aphanitic rocks are concerned. Many minerals of fundamental importance, such as nepheline and analcite, are often difficult to recognize in the groundmass of such rocks and can sometimes be detected only by a chemical analysis.

Again, the operation of the principle of solid solution, which is probably the most important physical-chemical factor in determining what minerals crystallize from a magma, often results in the development of 'hidden' molecules. Many minerals can take up free silica or other silicates in solid solution; for example, most of the extant analyses of nephelite show an excess of silica over that required for the formula $Na\,Al\,Si\,O_4$,[1] this excess being due to the presence of an isomorphous mixture, probably of albite and nephelite. The existence of such 'hidden' molecules is of great importance when the possibility of a rock reacting with the surrounding strata is considered. Such reaction depends on the degree of 'normative' saturation, which can in many cases only be determined by chemical means.

If the existence of a small modal amount of an unsaturated mineral is to be considered sufficient evidence to classify a rock as part-saturated, certain anomalies may arise. It is conceivable that the amount of free silica in solid solution might be sufficient to make up the deficiency in the unsaturated mineral, thus rendering the rock normatively saturated but modally part-saturated. From the petrological point of view, certain accessory minerals would tend to assume an exaggerated importance, with the result that, not only would anomalies arise in the classification of transition types, but also petrological affinities would be obscured. The difficulties introduced by this want of elasticity can be easily exemplified by a consideration of a few such transition types.

Some of the rocks, which have been described as pulaskite, have greater affinities with the monzonites than with the nephelite syenites, yet the presence of a trace of nephelite would necessitate their classification with the latter. On the other hand, an umptekite[2] may contain no apparent nephelite and yet be more closely akin to nephelite-syenite than to any other type. Some of the basaltic mugearites of the Kilpatrick Hills are olivine-free,[3] yet they have many affinities with the Jedburgh basalts, into which they grade by the appearance of labradorite and olivine. As Iddings has pointed out,[4] a minette can have the same composition as a leucite basalt, olivine and leucite being the high-temperature products of a magma which, if it has crystallized under plutonic conditions at a lower temperature, would have resulted in a mixture of orthoclase and

[1] Cf. Foote & Bradley, *Amer. Journ. Sci.* (4), xxxi, pp. 25–32, 1911.
[2] Rosenbusch, *Mikroskopische Physiographie*, 4th ed., ii, i, pp. 151–4, 1905.
[3] Tyrrell, Trans. Glas. Geol. Soc., xiv, p. 238, 1912.
[4] Quoted by Harker, *Science Progress*, vol. ii, No. 6, p. 242, 1907. See also Fouqué & Michel-Lévy, *Synthèse des minéraux et des roches*, 1882, p. 77.

biotite. Here we have a case where the volcanic representative of a saturated plutonic rock is a highly unsaturated rock.

A continuous sequence, with but little variation in composition, is often observed, from pyroxenite through wehrlite to dunite; nevertheless, olivine-free pyroxenite would have to be sharply discriminated from both wehrlite and dunite. The same remark applies to the allivalite-dunite series. Such examples, where the local, and sometimes apparently accidental, occurrence of an unsaturated mineral might widely separate closely related rocks, could be multiplied indefinitely. Enough has been said to show that the Principle of Saturation, applied in such an empirical fashion, is not sufficiently elastic, and also that it tends to obscure petrological affinities as well as the relative petrological values of minerals.

With regard to other classifications, there are several alternatives to Professor Shand's other than the silica-percentage one and Winchell's. Thus Tyrrell[1] has recently indicated the possibilities of a quantitative modal system. Many of the difficulties of such a system would disappear were more analyses of the groundmass of aphanites available, while in addition the 'typical' composition of constituent minerals could also be utilized. This author has also pointed out that one reason of Iddings' failure to correlate chemical with mineralogical composition is the fact that very few modes have been determined. At the present day any biological classification which was not primarily based on the phylogeny and ontogeny of species would not be considered. In view of the recent great developments in petrology, there seems no good reason why these two factors should not also be fully utilized in rock-classification. As Harker has said, "There are those who would have us abandon in despair all endeavour to place petrography on a genetic basis and fall back on a rigid arbitrary system as a final solution of the difficulty. This would be to renounce for ever the claim of this branch of geology to rank as a rational science."[2]

VII.—The Fossiliferous Molluscan Deposits of Wexford and North Manxland.

By Alfred Bell.

THE notes by Professor Grenville A. J. Cole & Mr. T. Hallissy on the Wexford Gravels,[3] and those by Dr. F. Cowper Reed on the Manxland shells in the Strickland Collection at the Sedgwick Museum, Cambridge,[4] published in last year's Geological Magazine, will be welcomed by geologists as drawing attention to an interesting but too long neglected subject. The principal object of this paper is to point out the faunal relations of the deposits in question to each other, and wherein they differ from those of the neighbourhood which are usually grouped with them, including the high-level shelly drifts of Moel Tryfaen, Macclesfield, Gloppa, and the Wicklow

[1] *Science Progress*, ix, No. 33, pp. 60–84, 1914.
[2] Rep. Brit. Assoc. Portsmouth, 1911, pp. 380–1.
[3] Geol. Mag., pp. 498–509, 1914.
[4] Op. cit., pp. 544–5, 1914.

Mountains, the limestone drifts and shelly clays of Ireland from Ballybrack Bay to Glenarm, and the stony or boulder clays of Cheshire and Lancashire.

In 1835 and 1836, when the study of glacial geology was in its infancy, Sir Richard (then Mr.) Griffith called attention to the marl beds in Wexford, "some of the shells appearing to correspond with those of the (English) Crag"—probably referring to a *Purpura* and *Neptunea contraria*. The gravel or marl he thought might possibly be of Norfolk Crag age, the shelly raised beaches of Ireland elsewhere being in his opinion distinctly newer.

In 1838 Edward Forbes figured a shell in the Malacologia Monensis found by him in the Isle of Man on the sea-shore, which his friend Hugh Strickland afterwards described as *Fusus Forbesii*. Forbes seems to have collected other shells in the Manx drifts, as in his well-known memoir of 1846 on the Fauna and Flora of the British Isles he mentions thirteen, including *Nassa pliocena*, *N. monensis*, and *Fusus Fabricii*.

In the same memoir he dealt also with the fossils found by Captain James in the neighbourhood of Wexford, of which he names about seventy species, including a number of extinct Pliocene or southern forms, as well as others of a distinctly northern facies, the whole suggesting to him "the probability of a communication southwards of the glacial sea, and a sea inhabited by a fauna more southern in character than that now existing" in the district. He says also on p. 44, "It can scarcely be doubted that during the newer Pliocene epoch there was a communication open between the Mediterranean and Northern Seas." He again alluded to the subject in 1859 in the *Natural History of the European Seas*, where on p. 114 he says, "I still stand by these opinions."

The next notice of the Wexford shells was in the lists published by myself in the Reports of the British Association for 1888 and 1890.[1] Somewhat later the Manxland fauna was dealt with by Professor Kendall (*Glacial Geology of the Isle of Man*, 1894) and by Mr. Lamplugh in the Survey memoir of the island (1903), their lists including all the species that had been recognized from that region.

More lately Mr. F. W. Harmer, examining the Rev. S. N. Harrison's collections of Manxland fossils, as well as that at the Jermyn Street Museum, discovered some other species of the older type, which he described, and figured in his recent work on the *Pliocene Mollusca of Great Britain*,[2] giving a list of twenty-two shells which he considers may represent a pre-Pleistocene fauna.

From personal acquaintance with both localities, and a fairly exhaustive one of the western faunas generally, I am led to the opinion that the Wexford and Manx beds form portions of a deposit *older* than that assigned to the great Irish Sea glacier, a view that has not been generally entertained. The only mainland molluscan fauna that can be tentatively collated with the Wexford–Manx Series is the one originally described by the late Mr. R. S. Darbishire[3]

[1] pp. 43, 410.
[2] Palæont. Soc., 1914, p. 123.
[3] Quart. Journ. Geol. Soc., vol. xxx, p. 38, 1874.

in a paper on some fossiliferous gravels at Worden Hall, Leyland, 5 miles south of Preston, Lancashire, in which he says "the assemblage of species as a whole most nearly represents that of the Wexford gravels, of which it may not be too wild to consider this deposit a Lancashire representation". Five or six years afterwards when Miss H. Ffarington, the original collector of the shells referred to, had largely augmented Mr. Darbishire's list of forty-three species, I had the pleasure of examining her collection, and was able to identify ninety species in it, which were afterwards recorded in a privately printed catalogue. Of these *Trophon Fabricii*, *Neptunea contraria*, and *Volumitra groenlandica* seem to connect the Worden deposit with that of Wexford and Manxland; but otherwise the fauna identifies itself more closely with that of the drifts of Ballybrack Bay, co. Dublin.

Below I have given three lists of the Mollusca found in Wexford and North Manxland that appear distinctive, the first containing the names of forty-one species, presumably Pliocene, not known to be living, the second of six species confined to seas south of Great Britain, and the third of thirty-three exclusively northern types. Of the total number of eighty species recorded, it may be said at once that only twelve (indicated in the lists by * and †) occur in any fossiliferous Pleistocene deposit elsewhere in Ireland, Wales, Lancashire, or North-West England, and these are all well-known living shells, the forms being absolutely strangers to any of these localities. The difference in the two faunal groups might be still further enlarged if species still living in adjacent waters were considered. Of the 104 shells collected in the Wexford–Manxland drifts only seventy-four species have been recorded from all the other Pleistocene horizons, the latter also yielding a number of species not yet known to the Wexford–Manx fauna.

Although the fossils of Wexford and the Isle of Man are not quite identical in species, it will be seen from the lists that they are of the same general character, and this resemblance is, I think, of more importance than their differences in details, differences that may be expected to disappear as the faunas of the two areas become better known. Crag workers know by experience that two sections of similar age in the same neighbourhood often vary considerably in their contents. On the other hand, the fossils of the high-level drifts and the shelly clays offer a striking contrast. Of the 140 or so species recorded in them not more than 24 or 25 are exotic, and these are chiefly northern. All the rest still live in the adjacent seas, and vary in their condition, preservation, and distribution.

The following analysis of the foregoing lists may be of interest as showing the distribution and range of the Wexford–Manx fauna in the separate areas.

	Wexford.	Manxland.	
Pliocene or not known living .	11	37	
Recent, but not British, Southern .	5	1	
,, ,, Northern .	18	28	
Still living in British waters .	72	80	
Total .	106	146	species in each area.

LIST OF THE MORE CHARACTERISTIC SPECIES OF MOLLUSCA OBTAINED FROM WEXFORD AND THE ISLE OF MAN, SHOWING THEIR GENERAL DISTRIBUTION AND THEIR AGREEMENT OR OTHERWISE WITH EACH OTHER.

PLIOCENE SPECIES.	Wexford.	Isle of Man.	Coralline Crag.	Red Crag.	St. Erth.	Other localities.
Cerithium tricinctum, Brocchi		x	x	x	x	Biot, Italy.
Columbella sulculata, S. V. Wood	x			x		
Conovulus pyramidalis, J. Sowerby	x		?	x	x	Slains.
Desmoulea conglobata, Brocchi		x	x	x		Italy.
Eulimella (?) *obtusa*, sp. nov.		x				
Euthria, sp. nov.		x				
Fusus longiroster, Brocchi		x				Biot, Italy.
F. Rigacii, Cerulli-Ireki		x				
Mitrella sp., Kendall		x				
Murex rudis, Borson		x			x	Italy.
M. Harrisoni, sp. nov.		x				
M. (*Ocinebra*) *tortuosus*, J. Sowerby, var. *minor*, F. W. Harmer		x	x	x		
var. *mona*, nov.		x				
Nassa consociata, S. V. Wood, var. *brevis*, F. W. Harmer		x		x		
N. elegans, Leathes		x		x		Slains.
N. granulata, J. Sowerby, var. *fenestrata*, F. W. Harmer		x		x		
var. *gracilis*, F. W. Harmer		x	x	x		
N. Kermodei, Kendall		x				
N. monensis, Forbes		x		x		
N. reticosa, J. Sowerby, var. *costata*, S. V. Wood	x	x	x	x		
var. *lineata*, F. W. Harmer		x		x		
N. Woodwardi, F. W. Harmer	x	x		x		
Neptunea contraria, Linné	x	x		x		Worden, Gloppa.
Raphitoma lævis, sp. nov.	x	x				
Searlesia costifer, S. V. Wood, var. *monensis*, F. W. Harmer		x				
var. β, J. Sowerby		x		x		
S. Forbesii, Strickland		x		x		
S. Harrisoni, A. Bell		x				
S. Kermodei, sp. nov.		x				
S. Lundgrenii, Mörch		x		x		Iceland.
S. Nordmanni, F. W. Harmer		x				
S. phyeni, F. W. Harmer		x				
Sipho curtus, Jeffreys, var. *exilis*, F. W. Harmer		x		x		
S. hibernicus, sp. nov.	x	x				
S. menapiæ, A. Bell	x	x				
S. tortuosus, Reeve, var. *lirata*, F. W. Harmer		x	x	x		
Trophon Bailyi, A. Bell	x					
T. Harmeri, sp. nov.		x				
T. Lamplughi, F. W. Harmer		x				
Turritella incrassata, J. Sowerby	x	x	x	x		
Acila Cobboldiæ, J. Sowerby	x			x		

Southern Species.	Wexford.	Isle of Man.	Coralline Crag.	Red Crag.	Other localities.
Cyprœa pyrum, Gmelin	x				
Fusus rostratus, Deshayes	x				
Nassa semistriata, Brocchi	x				
Leda pusio, Philippi	x				
Pectunculus pilosus, Linné	x		x	x	
Woodia digitaria, Linné		x	x	x	
Northern Species.					
Admete viridula, Fabricius		x		x	
†*Bela exarata*, Möller	x	x		x	
B. harpularia, Couthouy	x	x		x	
B. nobilis, Möller	x	x		x	
**B. pyramidalis*, Ström.	x	x		x	
B. rugulata, Möller		x		x	
B. scalaris, Möller	x			x	
Buccinum meridionale, Verkrüzen (MS.), var. *elongato-undosa*, Sparre Schneider (MS.)	x	x			
**Dentalium abyssorum*, G. O. Sars		x			
Meyeria alba, Jeffreys	x			x	
**Natica affinis*, Gmelin	x	x		x	
†*N. groenlandica*, Beck	x	x		x	
Parasipho Kröyeri, Möller		x		x	
Purpura incrassata, J. Sowerby	x	x		x	
**Scalaria groenlandica*, Chemnitz	x			x	
Sipho latericeus, Möller	x	x		x	
Taranis Mörchii, Malm		x			
**Trophon clathratus*, Linné	x	x		x	
†*T. Gunneri*, Lovén		x			
T. Fabricii, Beck		x			Worden.
T. lamellosus, Gray		x		x	
**Volumitra groenlandica*, Gray	x	x			Worden.
Astarte Banksii, Leach		x		x	
**A. borealis*, Chemnitz	x	x			
A. Richardsoni, Reeve		x			
A. semisulcata, Leach		x			
Mya uddevallensis, Forbes		x			
Nucula proxima, Gould	x				
Nuculana minuta, Möller, var. *tumida*		x			
**N. pernula*, Möller	x	x			
Serripes groenlandicus, Chemnitz		x		x	
**Tellina calcarea*, Chemnitz		x		x	
Yoldia hyperborea, Lovén	x				

* Occurring in the high-level drift of Wales, Cheshire, Staffordshire, and Lancashire; † in the shelly clays of North-East Ireland.

Of the 41 Pliocene species recorded above, 7 occur in both localities, Wexford and Manxland; of the 33 recent northern shells, 13 of them, and 50 of the recent British forms, are present in both.

It has been suggested that the beds in question contain a mixed collection of fossils derived from deposits of different ages, but this explanation seems to me improbable. They all have a similar appearance, and their mineral condition and conservation are the same. Furthermore, as specimens of the older type are found in areas so wide apart as Wexford and the north of the Isle of Man, one may fairly ask why no traces of such shells have been found in undoubted Pleistocene deposits on either side, or in the deep borings at the Point of Ayre in the north of the Isle of Man beyond the edge of the Shellag Sands, where the fauna is certainly of Pleistocene age. Another feature of the Wexford–Manx fossils may be worth notice, that is, the local abundance of certain species, such as *Buccinum*, var., *Purpura incrassata*, or a strong form, now lost, of *P. lapillus* and *Neptunea contraria*, whose "extinction as a race" Forbes referred to the upheaval of the Irish sandy beds. Of the latter species I have had as many as thirty at a time sent me from Blackwater, co. Wexford.

To my mind, we have on this western area several different stages in later geological history, of which this is one of the oldest: the admixture of Mediterranean Pliocene forms with those of Iceland justifying Forbes's suggestion of a former communication. The later deposits being of Pleistocene age are usually believed to have been brought into their present position by the action of the great Irish Sea glacier. However this may be, with many apologies to those who differ from me, I am *not* prepared to admit that the Wexford–Manx beds originated in the same way, differing as they do in their specific contents, method of distribution, and condition.

In conclusion, I desire to offer my best thanks to the Rev. S. N. Harrison and Mr. Kermode, of Ramsey, Isle of Man, and the Rev. Father Codd, of Blackwater, Wexford, for the loan and gift of many specimens; to the officers of H.M. Geological Survey, London, to Professor Cole and Mr. Hallissy, Dublin, and to Dr. Cowper Reed, Sedgwick Museum, Cambridge, for the opportunities of examining the various collections under their charge; and, not least, to my friend Mr. F. W. Harmer, for his kindly help, assistance, and suggestions for this paper.

The physical and local stratigraphical details I hope to be permitted to deal with later on, as seen from my point of view.

VIII.—New Fossiliferous Horizon in the Coniston Grits of Windermere.

By the Rev. Canon Crewdson, M.A.

FOSSIL remains in the Coniston Grit Series in the Lake District are generally so scarce, except in the flaggy beds exposed in the quarry near Latrigg on Applethwaite Common, that considerable interest attaches to the discovery, made in January of the present year, of a bed which is highly fossiliferous, in a quarry recently opened in connexion with the drainage works of Bowness and Windermere. The quarry is close to the shore of the lake, near the south-west corner of the Calgarth estate.

The newly exposed beds occur at an horizon some distance above the Latrigg band, but a good way below the overlying Bannisdale Slates. They appear to correspond in character with the band noted by Professor Hughes as occurring in the grits at Winder and Crook, about three-quarters of a mile north of Sedbergh [1]; but the matrix in which the Windermere fossils are embedded is much finer than the Winder rock, a condition which is frequently observed in comparing the correlatives of the two localities. It is possible that the Calgarth Beds are actually the equivalents of the Winder Grits; but as Professor Hughes states that the latter are within 1,200 feet of the base of the Coniston Grits of the Sedbergh district, and as the basal grits of that district are equivalents of the Upper Coniston Flags (Upper Coldwell Beds of Lakeland), the Calgarth seam may be at a higher horizon than that of Sedbergh. In any case the bands belong to the same general series, for the Winder Grit is in the coarser grits of Sedbergh, which represent the Coniston Grits of Windermere, and not in the lower flaggy grits which are equivalent to the Upper Coldwell Beds.

The fossils have generally weathered in bands which closely resemble those which are so frequently observed in the Kirkby Moor flags, the fossils being very crowded, but all the carbonate of lime of the shells has been removed. Better preserved fossils are sometimes abundant in the unweathered portions, but it is very rarely that the stone breaks so as to give a good exposure.

There is another quarry a few yards from that in which the fossils were found, but I was unable to find in it any trace of organic remains; it is, however, quite possible that some may yet be discovered, as my examination was unavoidably very cursory.

Dr. Marr, to whom I showed the specimens I procured, has very kindly had them named by Miss Elles, Sc D., according to the appended list. He has sent me the following paragraph from a work on the Geology of the Lake District which he is at present writing: "Prof. Hughes has described under the name of Crook and Winder Grit a coarse band of calcareous grit which is found among the Coniston Grits of the hills near Sedbergh. This grit may be also represented in the Lake District, and should be looked for. A specimen of yellow grit collected by Ruthven, and preserved in the Kendal Museum, is labelled 'Applethwaite'. It contains Monograpti, Crinoids, and Brachiopods, and may be a representative of the Winder Grit."

I think that the grit which I have described may be the deposit for which Dr. Marr has requested that search should be made, though, as stated above, it is not necessarily on the horizon of the Winder Grits, nor, so far as has been hitherto ascertained, does it contain any traces of Graptolites, like the specimen in the Kendal Museum.

I am greatly indebted to Dr. Marr for his help in preparing this paper, and also to Miss Elles for naming the fossils.

[1] See Memoirs of Geological Survey, Explanation of Quarter Sheet 98 N.E., pp. 14–6.

Miss Elles, Sc.D., has kindly furnished the following preliminary list of fossils from the deposits:—

Orthoceras sp.
Dalmanella (*Orthis*) *elegantula* (Dalm.).
Skenidium Lewisii (Dav.).
Cœlospira (*Atrypa*) *hemispherica* (Sad.).
Camarotœchia (*Rhynchonella*) *nucula* (Sad.).
Dayia (*Rhynchonella*) cf. *navicula* (Sad.).
Strophomena antiquata (Sad.).
Zygospira sp.
Murchisonia cf. *torquata* (McCoy).
Holopella cf. *tenuicincta* (McCoy).
Cyclonema sp.
Cornulites.
Monticulipora fibrosa (McCoy).
Crinoids, Bryozoans, and Corals, and perhaps Trilobites, but nothing identifiable.

REVIEWS.

I.—Memoirs of the Geological Survey.

The Geology of the South Wales Coalfield. Part XI: The Country around Haverfordwest, being an account of the region comprised in Sheet 228 of the Map. By Aubrey Strahan, Sc.D., F.R.S., F.G.S., T. C. Cantrill, B.Sc., F.G.S., E. E. L. Dixon, B.Sc., F.G.S., H. H. Thomas, M.A., B.Sc., F.G.S., and O. T. Jones, D.Sc., F.G.S. pp. i–vii, 1–262. 1914. Price 3*s.* 6*d.*

THE memoir before us deserves a somewhat extended notice, for much of its contents is of more than local interest. Were we to start our classification of the Lower Palæozoic rocks afresh, we should probably adopt this area as the type-area of the rocks of Ordovician age, and the lower division of the Silurian strata is also remarkably well represented. It is safe to say that students of the Ordovician and Lower Silurian strata will in future turn again and again to the pages of the memoir. The map of which the memoir is descriptive has not yet been published.

The district includes rocks of Pre-Cambrian, Cambrian, Ordovician, Silurian, Old Red Sandstone, Carboniferous, and Eocene (?) ages, and also Glacial and Post-Glacial accumulations.

The oldest rocks occur in two masses south of the coal-field, the southerly being termed the Benton Series (which also appears in a smaller patch further south) and the northerly the Johnston Series. The rocks of the former consist of acid lava-flows with tuffs and agglomerates which are probably of more basic character. The Johnston Series is one of plutonic rocks consisting (in the order of their intrusion) of quartz-diorites, quartz-albite rocks, and quartz-dolerites. The two series adjoin for about a mile, but the nature of the junction is unknown. The Rosemarket Rocks (of Valentian age) probably rest unconformably on the Benton Series, and the Johnston Rocks are also presumably older than the Rosemarket group. There are reasons for supposing that these Johnston Rocks are Pre-Cambrian, and it is likely that the Benton Series also should be referred to that age. Cambrian rocks of Lower Lingula Flag age are exposed on the east of the Western Cleddau at Spittal Cross and Trefgarn Bridge, and on the west of that river near Lewston and Wolfsdale.

The development of the Ordovician strata, notwithstanding certain breaks, is very complete, and the small thickness of intercalated

volcanic rock renders them easy of study; moreover, they show alternations of the 'shelly' and 'graptolitic' types of these strata.

The Arenig beds are representative of the lower (*Didymograptus extensus*) and upper (*D. hirundo*) zones so widely distributed elsewhere. The beds have not been separately mapped on account of the thinness of the *D. hirundo* zone, but are distinguishable on the ground. An ash occurs in the *extensus* beds of the Henllan Amgoed district, and a more important volcanic series consisting of lavas and tuffs developed near Trefgarn Bridge is probably on the same general horizon. The succeeding beds with *Didymograptus bifidus* are separated from the Arenig Series and placed in what Dr. Hicks termed the Llanvirn Series, characterized especially by 'tuning-fork graptolites'. In the Haverfordwest district the Lower Llanvirn beds (with *D. bifidus*) are alone represented, the Upper Llanvirn with *D. Murchisoni* being absent. Nevertheless it is interesting to find fossils hitherto referred to the Llandeilo, as *Ogygia Buchi* and *Calymene cambrensis*, in these beds. Indeed, the detailed survey of this area has shown the longer range of many other fossils of various strata.

The Llandeilo Series is divided into two groups of strata, the Llandeilo Limestone and Flags below and the lower part of the *Dicranograptus* beds above. These are dealt with in separate chapters. The lower group rests on the *bifidus* beds and decreases in thickness from south to north, with a corresponding diminution of the fauna. This suggests the existence of a land area to the south, with an east and west trend.

The *Dicranograptus* Shales are partly Llandeilo and partly Bala. They are subdivided into the basal Hendre Shales, the Mydrim Limestone, and the Mydrim Shales at the top.

The Hendre Shales are thinner than in the district to the east, partly owing to their lower part having passed laterally into the Llandeilo Limestone and Flags. They have a definite Llandeilo fauna. The surveyors draw the line between Llandeilo and Bala at the base of the Mydrim Limestone. This limestone has the graptolite fauna of the *Nemagraptus gracilis* beds, which Lapworth, when describing his classic sections at Moffat, correlated with part of the Llandeilo Series. One is disposed, therefore, to doubt the desirability of drawing the line where the Surveyors have placed it, and to avoid confusion would prefer to have it placed at a higher horizon.

The Mydrim Shales, as a result of Miss Elles' work in another Welsh area, have been divided into four graptolitic zones.

The Robeston Wathen Limestone with numerous corals shows evidence of overstepping the underlying strata. It has elsewhere been regarded as the upper division of the Caradocian division of the Bala Beds, the succeeding strata having been referred to the Ashgillian division. With this the Surveyors appear to agree.

The Shoalshook Limestone has long been known for the richness of its fauna. It forms the base of the Ashgillian representatives, and these Ashgillian strata are shown to rest unconformably upon the lower beds. This limestone from the presence of *Diplograptus*

(*Orthograptus*) *truncatus* (?) is assigned to either the upper part of the zone of *Dicranograptus Clingani* or the lower part of that of *Pleurograptus linearis* in the Scottish Southern Uplands. As *D.* (*O.*) *truncatus* var. *abbreviatus* is found in what appear to be corresponding beds in the neighbourhood of Sedbergh, along with *Dicellograptus anceps*, it may be suggested that the Shoalshook Limestone may possibly be on the horizon of the last-named zone.

The highest Ordovician strata, the Redhill–Slade Beds, exhibit a northern and a southern type. Fossils are rare in the northern type.

The Silurian beds belong to the Valentian (Llandovery–Tarannon Series). They seem in places to grade down into the highest Ordovician strata, though elsewhere a conglomerate occurs at the base. They are divided into three stages: these are, in ascending order, the Haverford, Millin, and Rosemarket stages. The beds of the last-named occur in a different tract to that showing the two former stages, being developed on the south side of the coal-field. "It may be observed that on the whole the Haverford stage corresponds to the so-called Lower Llandovery, while the Rosemarket stage may be matched with part of the Upper Llandovery, but there is difficulty in correlating the Millin stage with either of these subdivisions, and it probably forms a group which is only partly represented, if at all, in the district of Llandovery." The rich fossil lists from the Valentian beds of this district will be extremely valuable to future workers among the Llandovery rocks.

Passing to the Upper Palæozoic rocks, we find the Old Red Sandstone occurring both to the north and the south of the coal-field. The rocks differ widely in their characters. The beds are divided into a lower group consisting of red marls with sandstones, conglomerates, and breccias, and an upper group (the Skrinkle Sandstones). The Lower Old Red Sandstone is everywhere unconformable to the older rocks, while the Upper Old Red Sandstone is followed conformably by the Carboniferous strata. Both groups are absent near Haverfordwest, owing to westerly overstep of the Carboniferous rocks. The beds of the lower division have yielded *Pteraspis* and some plants, including *Psilophyton* (?).

The Carboniferous Limestone is also developed to the north and south of the coal-field. A closer comparison can be made between the northern beds and those further east, and also between the southern beds and their easterly equivalents, than between the northern and southern beds of the area under consideration. It is suggested that the area of deposition of these rocks in South Wales shallowed northward towards a coast with a general east and west trend.

The series corresponds in the main with the Avonian Series of Dr. Vaughan. The following zones are recognized in descending order:—

Dibunophyllum zone (lower sub-zone D 1 alone known).
Seminula zone.
Syringothyris zone.
Zaphrentis zone.
Cleistopora zone.

Evidence is given in favour of a division into Lower and Upper Avonian between the two subzones of the *Syringothyris* zone (where

an unconformity occurs), and not at the top of that zone. In connexion with this, interesting sections showing contemporaneous piping of mudstones into oolitic limestones of the lower part of the *Syringothyris* zone are described, and the phenomena are illustrated in two plates.

The Carboniferous Limestone in this area rests conformably upon the Old Red Sandstone, but is succeeded unconformably by the Millstone Grit: in neither case do we get information about faunas of passage beds between the Carboniferous Limestone and the older and newer strata.

The Millstone Grit is divided into three divisions, which do not show any features of exceptional interest.

The Coal-measures are naturally described in great detail. Only the eastern portion of the Pembrokeshire Coal-field is represented in the district of which the memoir under consideration is descriptive.

The coal-field here is broadly a syncline, but while the various subdivisions lie in normal superposition on the northern side of the trough, the central and southern portions are complicated by inverted folds and an almost infinite number of large and small overthrust faults. The basin here has been involved in two great belts of disturbance. On the south it is touched by the northern margin of the Armorican belt, with overthrusting and overfolding from the south; on the north it is affected by disturbances which also affect the Old Red Sandstone and Ordovician strata, and show evidence of overfolding and overthrusting from the north; in the centre there is comparatively little signs of disturbance.

The coals of this area are all anthracitic. The lower series, and probably only the lower half of that series, of the Coal-measures of Carmarthen and Glamorgan is alone represented in East Pembroke, and it is impossible to correlate with certainty the individual seams of this latter area with those of the former. Three seams have yielded the bulk of the coal, namely, the Rock, Timber, and Lower Level and Kilgelty veins.

There are no Triassic rocks in the district, but their former presence is indicated by reddening of the Carboniferous rocks.

Certain vein-quartz pebbles in a subsoil near Coedcanlas are noticed and referred to a possible Eocene date.

A very interesting chapter on Tectonics follows the description of the strata. The nature of the chief movements and their effects has already been noticed.

A raised beach overlain in one place by glacial drift corresponds both in position and age with one which occurs at intervals all around the Bristol Channel.

The glacial drifts are described, and a map on p. 218 indicates the distribution of the boulders and their directions of transport. There are also notices of river-terraces and of a submerged forest.

A chapter is devoted to economics, and notices lime and limestone, building stone, bricks, roadstone, timber, and water-supply. The character of the coal is dealt with in another memoir.

Four appendices treat of the fossils and of photographs of geological subjects belonging to the Geological Survey.

The method of indicating fossil localities in Appendix I should be specially noted. By means of this, and on consulting the 6 in. maps preserved in the Survey Office, the exact locality of any specimen may be ascertained. We may hope that this admirable example may frequently be followed by others, for nothing is more annoying than to find a vague locality given for an important fossil.

In congratulating all the authors of the memoir upon its matter, it may be remarked that while full credit is given to previous workers in the district for what they have done, the mistakes which they have made are touched upon so lightly that they can usually be detected only by consulting the original papers in which they appear.

J. E. M.

II.—The Water of Volcanoes.

In the Geological Magazine for 1911 the present writer reviewed a very striking book entitled *Recherches sur l'exhalaison volcanique*, written by Albert Brun of Geneva.[1] Brun's claim to have banished water-vapour from among true volcanic emanations has now been critically tested by Day & Shepherd[2] in its application to Kilauea, and has been satisfactorily disposed of. Brun has not laboured in vain, however, even apart from the many interesting side-issues which he has raised. One feels, on reading the account given by Day & Shepherd of their experiences, that the long-accepted belief in the importance of volcanic waters was in urgent need of direct confirmation. No experimenters could have entered upon the task with a greater prestige, and the result obtained will doubtless carry conviction. Those who imagine that the water of volcanic activity is a self-evident fact will be surprised to read that, although Day and Shepherd undertook their study of Kilauea on May 1, 1912, and waited till May 28 before an opportunity of collecting the gases at last arose, they were even then caught quite unprepared for the water which collected in their tubes; so much so that they had actually no apparatus ready at hand to estimate the proportion of the water to the other volatile matter discharged by the lava! Moreover, it will be remembered that Lowthian Green, who as a resident in the Hawaiian Isles enjoyed exceptional opportunities of observation, never subscribed to the prevalent aqueous theory of volcanoes.

Green's difficulties, it may be recalled, originated in his regarding the intensity of the great white cloud of the volcano as a measure of the vapours discharged. Where Green saw no cloud, he thought that but very little vapour was liberated. But Day & Shepherd prove that the cloud consists essentially of finely divided sulphur. Where the vapours are released into the atmosphere direct from the molten lava, they burn, and their products are invisible. It is only, where cooled down by passage through fissures of the shattered floor around the lava-lake, that the vapours yield the characteristic white cloud.

Brun's observation that the cloud consists of solid particles thus remains unchallenged. Brun noticed that the cloud when present

[1] See Geol. Mag., 1911, pp. 268, 311.

[2] A. L. Day & E. S. Shepherd, "Water and Volcanic Activity": Bull. Geol. Soc. Am., vol. xxiv, p. 573, 1913.

does not evaporate, that it gives no rainbows, and that it is immediately visible without an initial transparent zone, and these are just the results to be expected if the cloud contains much sulphur. But these phenomena, though they confirm Brun's statement that the great white cloud consists of solid particles, do not prove the absence of water; in passing it may also be mentioned that the impression one gathers from Brun's account that the solid particles of the cloud are crystallized salts must be revised.

Now it will be remembered that Brun made a series of experiments on the hygrometric state of the Kilauea cloud, and found it uniformly lower than that of the atmosphere outside. This observation serves as a corner-stone in Brun's statement of his case, but is set aside by Day & Shepherd as quite untrustworthy. The cloud, it seems, was sampled more than 250 feet from the point of emergence of the gases, while the presence of oxides of sulphur must in any case have lowered the dew-point very considerably.

Thus it appears that Day & Shepherd have kept in view the work of their predecessors, and thereby materially strengthened the presentation of their own results.

The following are the circumstances under which they successfully collected the volcanic gases. A column of lava had worked its way through the shattered floor adjacent to the great active basin, and formed a lava-fountain several feet in diameter. The lava quickly built up a closed spatter-dome, and at night gases could be seen burning as they escaped through narrow cracks. It was clear that an excess of pressure reigned within the dome, and that there was no fear of admixture with air.

The gases were drawn by a pump from the interior of the spatter-dome. Twelve inches of iron pipe were inserted into the dome, and behind this were 20 feet of glass tubing. The gases entered at about 1,000° C. Water began condensing in the pipe-line with the first stroke of the pump. This prevented quantitative determinations of proportions, for before sealing the tubes the pumping had to be continued fifteen minutes to ensure the complete displacement of the air present, and all this time water was collecting. In the end about 300 c.c. of water accumulated in the tubes.

The gases found were mainly SO_2, CO_2, and N_2, with less abundant H_2 and CO. Hydrocarbons were absent, while chlorine, free or combined, played a very subordinate role.

The water is regarded as proper to the volcanic emanation on the following grounds:—

1. CO_2 and H_2 cannot coexist at 1,000° C. without the production of water.

2. The FeO, resulting from the interactions of the short iron tube and the SO_2, is not likely to have been more efficacious in oxidizing the hydrogen of the emanation than the 10 per cent. of ferrous oxide present in the magma.

3. If the water collected represents hydrogen in the original emanation, then hydrogen must constitute at least 40 per cent of the emanation. This would entail violent explosions whenever the emanation is liberated into air, but as a matter of observation

bubbles of gas, even 30 feet in diameter, burst without giving any explosion whatever.

The nitrogen of the emanation was handed over to Professor R. W. Wood for examination for rare gases. The result was negative; and the absence of argon is taken as a further proof that the volcanic gases had been successfully collected free from atmospheric contamination. It is further held by the authors as an indication that the magmatic nitrogen was not originally atmospheric in origin. Here it seems to the writer that there is room for doubt. Is it not possible that nitrogen possesses an advantage over argon either in the process of diffusion through solid rock-masses or perhaps in that of solution by silicate magmas? However, Day & Shepherd are satisfied that magmatic nitrogen is an essentially original constituent, and conclude that magmatic water is in all probability in a like category; for water above its critical temperature loses the advantage due to surface tension, which is the basis of Daubrée's famous experiment.

E. B. Bailey.

III.—The Deposits of the Useful Minerals and Rocks, their Origin, Form, and Content. By Professor Dr. F. Beyschlag, Professor J. H. L. Vogt, and Professor Dr. P. Krusch. Translated by S. J. Truscott. In three volumes. Vol. I: pp. xxviii+514, with 291 illustrations. London: Macmillan & Co., Ltd., 1914.

THE authors of the original German edition, all three of whom are among the foremost living authorities on the subject, have planned a most comprehensive and ambitious treatise on ore-deposits. When they complete their project they will have included within their purview not only ore-deposits as ordinarily understood, that is to say those metalliferous in character, but also deposits of coal, salt, and mineral oil, and will have therefore covered the whole range of minerals and rocks which have been mined. The first volume appeared in 1910; the second volume was published in two parts, the first in 1912 and the second in 1913. This treatise differs from the earlier standard works on the subject (viz., Dr. Richard Beck's *Lehre von den Erzlagerstätten*, of which a third edition appeared in 1910, and *Die Erzlagerstätten*, began by Professor Stelzner and completed by Dr. Alfred Bergeat, which was published in parts, i and ii in 1904 and iii in 1906) in that the discussion is based upon broad geological principles; while in the two works mentioned the tendency has been more to bring together copious and detailed descriptions of the important mining regions.

The volume we have before us is the English translation of the first volume of the German edition. The task of preparing the translation has been undertaken by Mr. S. J. Truscott of the Royal School of Mines, London, and has been admirably performed. In his preface he modestly says, "I have endeavoured faithfully to bring out both the fact and the spirit of the authors' work, this being of such high standard that the reception of a translation must depend largely upon the degree of closeness with which the original is approached." There can be no question of his success, but, we may add, he has not adhered so slavishly to the original as to mar the ease of diction:

there is nothing, beyond the fact that many of the illustrations are drawn from the collection of the Geologische Landesanstalt in Berlin, to suggest the original foreign source. He has been at great pains to study the precise meaning of the technical words, and in his preface gives an interesting essay on the subject. The German word *Gang*, for instance, may be translated as either 'lode' or 'vein'; the latter has a similar sense to the former, but is of a less important character, though, it is pointed out, the meaning has been somewhat confused by the vagaries of American Law phraseology.

The first volume includes five principal parts: viz. on ore-deposits in general, magmatic segregation, contact-deposits, tin-lodes, and quicksilver lodes. Neither the parts nor the chapters comprising them are numbered. The first part occupies nearly half the volume, and includes such important chapters as those on classification, form and graphic representation of ore-deposits, mineral formation, the relative distribution of the elements and their natural associations with especial reference to the metals, the origin of ore-deposits, the absolute and the relative amounts of the metals in useful ore-deposits, primary and secondary depth-zones, indications of ore-deposits at the surface, and the scientific classification of ore-deposits. A conspicuous and important feature of the book is the excellent bibliography that heads each section, the student being thereby placed in touch with all the principal books and memoirs written on the subject in question.

Probably the reader already acquainted with the subject will first look to see what classification has been adopted by the authors. Many systems have from time to time been suggested, all of which are referable to three different types, viz. according as they are based upon the shape, the content, or the genesis of the deposit. The first has much to commend it from the practical mining, and the second from the commercial point of view, but neither can be defended on scientific grounds, and the third alone remains. Like most recent writers, the authors adopt a classification based upon Stelzner's and divide deposits into two main groups—the syngenetic, ores formed contemporaneously with the rocks surrounding them, and the epigenetic, ores formed subsequently. In a later chapter they put forward a complete scientific classification consisting of four main groups: I, magmatic segregations; II, contact deposits; III, cavity fillings and metasomatic deposits; IV, ore beds. In a second edition they will no doubt include some reference to the highly interesting and cogent paper which Mr. T. Crook, of the Imperial Institute, read before the Mineralogical Society, and published in the *Mineralogical Magazine* last July. In it he considers the classification of rocks, regarding ore-deposits rightly as only a special case of the problem, and points out grave objections to all the existing schemes of classification. For instance, Stelzner's main groups often unite the different and separate the similar; to quote Mr. Crook, "Thus ore deposits resulting from igneous activity may be either 'syngenetic' or 'epigenetic'; the 'syngenetic' group includes both igneous segregations and sedimentary deposits; and vein deposits are 'epigenetic' whatever may have been the origin of the solutions from which they have been deposited." He himself

suggests a grouping based upon a genetic geological basis, as follows: I. Endogenetic deposits: (1) igneous segregations, (2) igneous exudations, (3) deposits in thermo-dynamically altered rocks (unfused and unimpregnated). II. Exogenetic deposits: (1) weathering residues, (2) detrital deposits, (3) solution deposits, (4) subaerial plant accumulations and their products.

Many famous mineral localities are incidentally described in this volume: among them may be mentioned the gold-telluride mines in Western Australia and Colorado, the quicksilver mines at Almaden, the Broken Hill silver-lead mines, the Burra Burra copper mines, the famous Swedish iron deposits, the pyrites deposits at Rio Tinto, the Saxon–Bohemian Erzgebirge, the Straits Settlements tin deposits, and the Cornish mines.

The volume is admirably illustrated and provided with excellent subject and geographical indices, and is altogether one that should find a welcome home on the shelves of all who are interested in either rocks in general or ore-deposits in particular.

IV.—Brief Notices.

1. The Production of Mineral Waters in 1913; with a Discussion of their Radio-activity. By R. B. Dole. Mineral Resources of the United States, calendar year 1913. Part II. pp. 393–440. 1914.

THIS report contains statistics of the natural mineral waters of the United States, arranged according to States. It includes two features of interest: a bibliography of mineral water analyses, and a short account of the radio-activity of mineral waters. Many mineral waters do not differ in any obvious way from ordinary town supplies in their composition. Yet such waters have a distinct therapeutic value, and in recent years the previously obscure curative agent has been identified with radio-active ingredients which the medicinal waters have been found to contain. A table showing the radio-activity of about fifty well-known waters is given, but unfortunately the radio-activity is expressed according to five different units, and direct comparison is thus impeded. A bibliography is provided of literature bearing on radio-activity and radio-therapy, and is a useful compilation; but one notices the rather serious omission of Sir E. Rutherford's *Radio-active Substances*, 1913, which should have taken the place of his 1906 book.

2. Portuguese East Africa.—Messrs. E. O. Thiele and R. C. Wilson publish in the *Geographical Journal* for January, 1915, a tectonic and physiographic account of the area between the Zambesi and Sabi Rivers. But in the discussion, which followed, are some remarks by Mr. R. B. Newton on important fossils collected, and these remarks are liable to be overlooked. The collection is now in the British Museum, and belong to Upper Cretaceous, Lower Eocene, and Miocene times. The latter is recognized for the first time from the presence of the foraminiferal genus *Amphistegina*; whereas the Eocene was identified from *Nummulites* as far back as 1896 (Geol. Mag., 1896, 487) from material collected by David Draper about 100 miles south of the area whence Mr. Thiele obtained his specimens.

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.

Annual General Meeting.

1. *February* 19, 1915.—Dr. A. Smith Woodward, F.R.S., President, in the Chair.

The Reports of the Council and of the Library Committee were read.

The Awards of the various Medals and Proceeds of Donation Funds in the gift of the Council were enumerated.

The Reports having been received, the President handed the Prestwich Medal, awarded to Dr. Émile Cartailhac, to Baron Prosper de Barante, Secretary of the French Embassy, for transmission to the recipient, addressing him as follows :—

Baron de Barante,—The Council of the Geological Society has awarded the Prestwich Medal to Dr. Emile Cartailhac, the Nestor of French archæologists and the acknowledged leader of that brilliant band of French investigators who have shed so much unexpected light on the life of man in the Pleistocene Epoch.

Dr. Cartailhac's long-continued labours, extending over half a century, have been crowned by the two noble volumes which adorn the series published by the munificence of the Prince of Monaco. The treatise on the Archæology of the Grottes de Grimaldi is a most valuable contribution to our knowledge of Aurignacian culture, and shows in the clearest manner the cult of the dead which prevailed among the later Palæolithic peoples. The great work on the Spanish Cave of Altamira is a masterpiece of scientific investigation, to which all must turn who would appreciate those remarkable achievements in art that are the glory of the later Palæolithic age.

To his scientific powers and attainments, originality and lucidity, Dr. Cartailhac adds a greatness of mind ready to suffer all things in the cause of truth, and a personal sympathy with his younger colleagues which is the offspring of a natural kindness of heart. The Geological Society has long admired both the man and his work, and will be glad if you will transmit this medal to him as a small mark of its esteem.

Baron de Barante replied in the following words :—

Mr. President,—M. Cambon would have had great pleasure in acknowledging personally the honour bestowed by the Geological Society on Dr. Cartailhac. He has asked me to tell you how sorry he is to have been unable to be amongst you on the present occasion.

The Prestwich Medal is a token of esteem which I am glad to accept on behalf of Dr. Cartailhac, who will value very highly, not only your gift, but also the kind way in which the Geological Society appreciates his labours.

May I add that your words have for us another and a wider meaning? They show once more how tight have grown the bonds between our two nations through the long-standing brotherhood of England and France in the field of scientific knowledge. We have fought side by side for years in the cause of truth and enlightenment, just as we are now together on the battlefield up in arms for the rights of nations, for justice and for liberty.

The President then handed the Wollaston Medal, awarded to Professor T. W. Edgeworth David, C.M.G., to the Right Hon. Sir George H. Reid, P.C., G.C.M.G., High Commissioner for the Commonwealth of Australia, for transmission to the recipient, and addressed him as follows :—

Sir George Reid,—The Council of the Geological Society has this year awarded the Wollaston Medal, its highest distinction, to Professor Edgeworth

David, in recognition of the value of his contributions to our knowledge of the geology of Australasia and the Antarctic regions. Since his appointment to the Geological Survey of New South Wales in 1882, and his subsequent call to the Chair of Geology in the University of Sydney in 1891, Professor David has taken a foremost part in the promotion of geological science in the Australian Commonwealth. His researches on glacial conditions in the Permo-Carboniferous Period, and on the chief tectonic lines of the Australian Continent, have touched problems of the deepest philosophical interest; while his exhaustive works on some of the Australian coal-fields have shown that he is not unmindful of the economic needs of a newly settled country. The energy and skill with which he brought the boring in the coral-atoll of Funafuti to a successful termination will always be remembered with gratitude and admiration by geologists; while his bold venture to take a personal share in the hardships and dangers of exploration on the Antarctic Continent enabled ripe experience to bear on the interpretation of geological phenomena which might have been deemed accessible only to those in the first vigour of youth. We still await the detailed report on Professor David's work during the Shackleton Antarctic Expedition, but his preliminary communications have already allowed us to judge of its real importance.

Professor David has already received many marks of appreciation in Australia, where his kindly nature has endeared him both to colleagues and to students. He is a past president of the Royal Society of New South Wales, and of the Australasian Association for the Advancement of Science; and he was Chairman of the New South Wales Committee which made arrangements for the recent visit of the British Association. The Council of the Geological Society will now be glad if you will convey to him the Wollaston Medal as a renewed token of its esteem and appreciation, with an expression of the cordial wishes of the Society for his continued health and activity.

Sir GEORGE REID, in reply, expressed the pleasure which it afforded him to represent on that occasion an old and valued friend. He dwelt on the great scientific work which Professor David had accomplished in and for Australia, and mentioned that to his expert knowledge Ministers had invariably had recourse when they needed advice on matters connected with science. Not only was Professor David revered in Australia for his scientific attainments, but the charm of his personality and the kindliness of his nature endeared him to all those who knew him.

In presenting the Murchison Medal to Professor William Whitehead Watts, F.R.S., the President addressed him in the following words:—

Professor WATTS,—The Council congratulates itself that, owing to the circumstance of your now resting from the responsibilities of office for the first time during some sixteen years, the opportunity is afforded to it of expressing its deep sense of the many obligations which geological science owes to you and to your researches. It is therefore conscious of more than ordinary appropriateness in awarding to you the Murchison Medal, which recalls the memory of the pioneer who made famous the rocks of your native county, Shropshire, and laid the foundations on which you have so admirably based a superstructure. Your researches have extended from Shropshire to the English Midlands, Wales, Scotland, and Ireland, and among your writings known and prized by the rising generation of British geologists, I need only mention your brilliant papers on Charnwood Forest, the igneous rocks of the Midlands, and the Collection of Rocks and Fossils belonging to the Geological Survey of Ireland. Your energies and interests in all branches of geology have passed far beyond the range of an ordinary investigator; and as a teacher of geology you have infected with your enthusiasm numberless students, who have been charmed by the method and clearness of your presentation of the subject, both in the lecture-room and in the field.

In offering you this mark of its appreciation, the Council desires to express the hope that you may long be spared to continue your invaluable service to the progress of our science.

Professor Watts, in reply, said:—

Mr. President,—It gives me much pleasure personally to thank the Council for their award of the Murchison Medal, and yourself, Sir, for the kind and encouraging words in which you have made the presentation. The flattering reference that you have made to my work, while showing how deeply I am indebted to my Cambridge teachers Professor Hughes and Professor Bonney, makes only too clear to me how far performance halts behind ideals.

My long service as Secretary of the Society, my former membership of the Geological Survey, and my share in Professor Lapworth's work in the county where the founder made his classic discoveries, unite in making me proud to possess the Murchison Medal. But there is still another reason why the award is doubly gratifying to me at the present time.

After dwelling in the wilderness for many years, the great institution founded by De la Beche and presided over by Murchison (who allowed it to share the die of his Medal) enters this year into full possession of the beautiful home which has been erected for it at uncounted cost by the Governing Body of the Imperial College. That this learned and representative Society should mark the reincarnation of the Royal School of Mines by sending to it such an appropriate recognition, cannot but be a source of deep gratification to Professor Judd, who designed the practical geological teaching there, to my Staff, who have striven worthily to carry on and extend his methods, to my colleagues in the arts and sciences of Mining, Metallurgy, and Oil-getting, and to the authorities of the Imperial College, who have spared neither thought nor resources in giving to De la Beche's conception a form worthy of it, have placed research in the forefront of the functions of the College, and have permitted the Geological Museum therein to bear the honoured name of Murchison.

The President, in presenting the Lyell Medal to Professor Edmund Johnston Garwood, F.R.S., addressed him as follows:—

Professor Garwood,—The Lyell Medal is awarded to you by the Council as a token of its appreciation of your many and notable contributions to geological science. In Glaciology your investigations in the English Lake District, Spitsbergen, the Alps, and the Himalayas, are of fundamental importance; and, as an example of the care with which your work is presented for publication, I need only mention your beautifully illustrated paper on the Tarns of the Canton Ticino in our Quarterly Journal for 1906. In Stratigraphy your long and patient study of the Lower Carboniferous rocks in the North-West of England has resulted in the recognition of a zonal sequence which must be taken as a standard for comparison in all future work on the corresponding formations of the British Isles. In Palæontology you have recently drawn special attention to the importance of Calcareous Algæ as rock-builders, and have already made much progress in the detailed study of their structure.

The Society has followed your researches with sympathetic interest for many years, and, as a former colleague in the Secretaryship, it gives me great pleasure to hand you this medal.

Professor Garwood replied in the following words:—

Mr. President,—I am deeply sensible of the honour which the Council of this Society has conferred on me by the award of the Lyell Medal.

The infinite variety and unfailing interest of the problems that confront the geologist in any original research, in themselves, provide sufficient compensation for the labour expended; but the sympathy and appreciation of fellow-workers is a real and valuable stimulus, and a permanent source of gratification and encouragement.

In glancing at the list of names of former recipients, I notice that the first award of this medal was made to the late Professor John Morris, my predecessor in the Chair of Geology at University College, and it is a great satisfaction to me that the work carried on in the Geological Department at the College should have again received recognition at the hands of this Society. The work

entailed in the discharge of official duties connected with the chair leaves but scant leisure for original research; and even the little that I have been able to accomplish towards the furtherance of our science would have been even less but for the ungrudging assistance which I have received in the field from many of my former students.

Passing down the list, my attention is arrested by the name of Dr. Marr—a name which brings vividly before me the debt that I owe to the School of Geology at Cambridge. As in the case of the founder of this medal, the subject of Geology was not included in the course of study which had been mapped out for me on my entrance to the University, and just as Lyell's interest was first aroused by Dr. Buckland's lectures which he attended at Oxford, my enthusiasm was stimulated by the courses delivered by Professor Hughes and Dr. Marr at Cambridge, and I am glad of this opportunity of expressing how much I owe to their help and kindness during my Cambridge career.

To Dr. Marr I am further indebted for his constant encouragement in connexion with my work on the Lower Carboniferous rocks in Westmorland, without which it is doubtful whether the investigation would have ever been brought to a successful conclusion.

To another of my predecessors, Professor Bonney (whose wide sympathies are so well known to the Fellows of this Society), I owe much for his constant kindness and interest in my work, more particularly in the development of certain heresies connected with the interpretation of glacial phenomena.

You have been good enough to allude to my interest in the part played by the Calcareous Algæ as rock-builders. I may therefore perhaps point out that my work in this direction is really a continuation of Lyell's investigations on the same subject, for it was Lyell himself who first called our attention to the importance of plants as agents in limestone formation, in his paper published in the Transactions of this Society in 1829, in which he records the formation of nodules and strata of travertine in a lake near his old home in Forfarshire.

I thank you, Sir, for the kind words with which you have accompanied this presentation; it is an especial pleasure to receive this medal from the hands of one with whom I lately shared the duties of Secretary to this Society.

The President then handed the Bigsby Medal, awarded to Mr. Henry Hubert Hayden, Director of the Geological Survey of India, to Sir Thomas Henry Holland, K.C.I.E., for transmission to the recipient, addressing him as follows:—

Sir THOMAS HOLLAND,—The Bigsby Medal has been awarded by the Council to Mr. Henry Hubert Hayden, in recognition of the value of his contributions to our knowledge of the Geology of India. His work touches nearly every phase of geological inquiry, and includes field observations in most provinces of the Indian Empire as well as beyond its frontiers in Tibet and Afghanistan. His exhaustive memoirs on the Central Himalayan region of Spiti, on Kashmir, on Eastern Tibet, and on Afghanistan are mainly concerned with palæontological and stratigraphical problems, but they include also important observations on the physical geography of each region, on the igneous rocks of all, and on their phenomena and metamorphism.

During the past three years, although occupied with administrative duties as Director of the Geological Survey of India, he has found time to make a new excursion beyond the borderland of his subject, in a suggestive discussion of the relations between the geodetic observations and the geological features of the Indo-Gangetic alluvial plain.

A cursory survey of the titles of his papers leaves the impression that they are mainly regional and descriptive in character; a closer study of their contents, however, shows that they add materially, not only to our stock of data, but to the wider philosophical bearings of nearly every branch of geology. They are not the products of the mere student, for the observations which they describe are those that could have been made only by an intrepid explorer,

by an expert mountaineer, and by one who possesses, in a pronounced degree, the leading trait of British pioneers in "new lands"—a capable leader of men.

In accordance with the will of its founder, the Bigsby Medal is always given to one who is "probably not too old for further work, and not too young to have done much". In transmitting the award to Mr. Hayden, the Council will therefore be glad if you will also convey its best wishes, with an assurance of its continued interest in the future successful work which it anticipates.

Sir Thomas Holland, in reply, said:—

Mr. President,—My long and intimate personal acquaintance with Mr. Hayden gives me ample justification for assuring the Society that the Council has observed with rigour the terms of the Bigsby Bequest, which expect of the medallist promise of future work in continuation of a meritorious past. No award could give my old colleagues of the Indian Geological Survey greater satisfaction, for they know why I have special reason to regard this honour as abundantly earned.

Both before and during my term of office as Director of the Geological Survey of India, Mr. Hayden was most conspicuously the "handy man" of the Department. He was always ready to face any emergency, regardless of geographical, climatic, or political difficulties; and, as a consequence of the numerous demands made for his official services, his published record, which you, Sir, have now justly reviewed, represents but a fraction of his official and scientific activities.

In thanking the Council in the name of Mr. Hayden and on behalf of the service which he so ably leads, I gladly undertake the duty of forwarding this medal.

In presenting the Balance of the Proceeds of the Wollaston Donation Fund to Mr. Charles Bertie Wedd, B.A., the President addressed him in the following words:—

Mr. Wedd,—The Balance of the Proceeds of the Wollaston Donation Fund is awarded to you as an acknowledgment of the value of your geological work.

At Cambridge you dealt with several problems connected with the local geology, and, later, as a geological surveyor, continued your investigations in the counties of Bedford and Huntingdon. Your work on the Jurassic and Cretaceous rocks has not been confined to England, and our knowledge has been enriched by your careful mapping of these deposits in the Western Isles of Scotland. Latterly, your efforts have been directed chiefly towards the elucidation of Carboniferous stratigraphy. An absorbing interest in field-work, and a patient collection of detail, enabled you to interpret successfully the structure of a most complicated portion of the North Staffordshire Coal-field. Your work on the Carboniferous Limestone and Fluorspar deposits of Derbyshire was a valuable contribution to our science, and your observations on the Glacial History of our Islands, although scattered through a variety of official publications, are of considerable interest. In making this award the Council feels confident that your future work will be as successful and valuable as that which you have already accomplished.

The President then handed the Balance of the Proceeds of the Murchison Geological Fund, awarded to Mr. David Cledlyn Evans, F.G.S., to Mr. T. C. Cantrill, B.Sc., for transmission to the recipient, addressing him as follows:—

Mr. Cantrill,—The Council has this year awarded to Mr. David C. Evans the Balance of the Proceeds of the Murchison Geological Fund, in acknowledgment of the value of his researches among the Lower Palæozoic rocks. During the lifetime of his fellow-countryman, the late Dr. Henry Hicks, he was led to study the complex geology of parts of Western Carmarthenshire, and in 1906 he brought his labours in the St. Clears district to a very successful issue, as shown by his exhaustive paper in our Quarterly Journal. His natural enthusiasm in the pursuit of knowledge, particularly in the fields of geology

and archæology, has in the past induced him to find time for original research in the midst of scholastic duties. We hope that in the near future his continued labours will produce equally good results.

In presenting one moiety of the Balance of the Proceeds of the Lyell Geological Fund, awarded to Dr. Lewis Moysey, B.A., the President addressed him in the following words:—

Dr. MOYSEY,—The Council has awarded to you a moiety of the Proceeds of the Lyell Fund in recognition of the value of your work on the fossils of the Derbyshire and Nottinghamshire Coal-field. Your contribution to a recently published Geological Survey memoir shows the wide range of the investigations which you have carried on in the intervals of a busy professional life. Not only have you added considerably to our general knowledge of the coal-field, but by the exercise of great patience and skill, and by using a novel method to obtain satisfactory material from a most unpromising matrix, you have discovered several rare as well as new forms of Crustacea, some of which you have described. You have also taken up with enthusiasm the study of those palæontological outcasts, *Palæoxyris*, *Vetacapsula*, and *Fayolia*. The Council anticipates with confidence further results from your researches, when you are freed from military duties and can resume your favourite studies.

The President then handed the other moiety of the Balance of the Proceeds of the Lyell Geological Fund, awarded to John Parkinson, M.A., to Professor T. G. Bonney, F.R.S., for transmission to the recipient, addressing him as follows:—

Dr. BONNEY,—The Council has awarded to Mr. John Parkinson a moiety of the Lyell Fund in acknowledgment of the value of his numerous contributions to geology, chiefly made in the intervals of arduous duties when conducting mining surveys in various parts of the world. He studied engineering at University College, London, and there acquired a sound knowledge of geology, which was afterwards increased at Cambridge. He at once proceeded to do excellent service to our science, and among the most important of his early petrological contributions may be specially mentioned his studies of the relations of the granites to the diorites in the northern and eastern parts of Jersey, and the light thrown by the hollow spherulites in the obsidian of the Yellowstone Park on the so-called 'pyromerides' of Boulay Bay. The value of his work on the Guernsey diorites must not be forgotten, nor of that in Northern Pembrokeshire and near Tintagel. He has touched with good effect on the lake-basins of the Canadian Rocky Mountains, and on the petrology of Ceylon and India. During more recent years he has also made notable contributions to our knowledge of the geology of Southern Nigeria, the Gold Coast, and Liberia. I shall be glad if you will convey this award to Mr. Parkinson, with the Council's best wishes for the continued success of his researches in the future.

In presenting the Proceeds of the Barlow-Jameson Fund to Mr. Joseph G. Hamling, F.G.S., the President addressed him as follows:—

Mr. HAMLING,—The Council has awarded to you the Proceeds of the Barlow-Jameson Fund as a mark of its appreciation of your geological work in North Devon, and as an encouragement to further research. For many years you have collected the rare fossils from the Culm and Devonian rocks of the county in which you reside, and have made numerous important observations on their stratigraphical arrangement. In the report of the excursion of the Geologists' Association to Barnstaple in 1910, you published a useful summary of your results in that district; and you have also contributed to the Transactions of the Devonshire Association and the Somersetshire Natural History Society. As one who has had the privilege of accompanying you in the field on many occasions, I have great pleasure in handing to you this award.

The President thereafter proceeded to read his Anniversary Address, giving obituary notices of Eduard Suess (elected a Foreign Member in 1877), and of the following Fellows: A. J. Jukes-Browne (el. in 1874), the Rev. Osmond Fisher (el. 1852), William Hill (el. 1885), H. J. Johnston-Lavis (el. 1875), F. W. Rudler (el. 1870), the Rev. J. M. Mello (el. 1865), W. Cash (el. 1873), A. R. Hunt (el. 1870), W. E. Darwin (el. 1881), L. V. Dalton (el. 1908), E. D. E. Isaacson (el. 1908), Baron Merthyr (el. 1867), and T. Stephens (el. 1873). He also referred to the death of Sir John Murray, K.C.B.

The President remarked that the progress of Geology depends on so many lines of research, that each specialist does well at times to pause and consider the relation of his own small part to the whole. He therefore reviewed some results of his study of fossil fishes in their bearing on stratigraphy. However necessary detailed lists of species of fossils might be for comparative work with sediments in restricted areas, he hoped to show that in dealing with broader questions names were really of small importance. Certain general principles had been arrived at, which would serve for all practical purposes. Each successive great group of fishes began with free-swimming fusiform animals, of which some passed quickly into slow-moving or grovelling types, while others changed more gradually into elongated or eel-shaped types. There was also a constant tendency for the primitive symmetry of the parts of the skeleton in successive members of a group to become marred by various more or less irregular fusions, subdivisions, and suppressions. Some of the successive species of each group increased in size, until the maximum was reached just before the time for extinction. These and many other more special inevitable changes had now been traced in most groups, and the various geological dates at which they occurred had been determined by observations on fossil fishes from many parts of the world. Even fragments of fish-skeletons, too imperfect to be named, were often therefore of value for stratigraphical purposes.

The Ballot for the Officers and Council was taken, and the following were declared duly elected for the ensuing year :—

OFFICERS.—*President:* Arthur Smith Woodward, LL.D., F.R.S. *Vice-Presidents:* Henry Howe Bemrose, J.P., Sc.D.; Clement Reid, F.R.S., F.L.S.; Aubrey Strahan, Sc.D., LL.D., F.R.S.; and the Rev. Henry Hoyte Winwood, M.A. *Secretaries:* Herbert Henry Thomas, M.A., Sc.D.; and Herbert Lapworth, D.Sc., M.Inst.C.E. *Foreign Secretary:* Sir Archibald Geikie, O.M., K.C.B., D.C.L., LL.D., Sc.D., F.R.S. *Treasurer:* Bedford McNeill, Assoc. R.S.M.

The other Members of COUNCIL elected were: Professor Charles Gilbert Cullis, D.Sc.; R. Mountford Deeley, M.Inst.C.E.; John William Evans, D.Sc., LL.B.; Professor William George Fearnsides, M.A.; Walcot Gibson, D.Sc.; Sir Thomas Henry Holland, K.C.I.E., D.Sc., F.R.S.; Professor Owen Thomas Jones, M.A., D.Sc.; Finlay Lorimer Kitchin, M.A., Ph.D.; John Edward Marr, M.A., Sc.D., F.R.S.; Edwin Tulley Newton, F.R.S.; Robert Heron Rastall, M.A.; Professor William Johnson Sollas, M.A., Sc.D., LL.D., F.R.S.; J. J. Harris Teall, M.A., D.Sc., LL.D., F.R.S.; William Whitaker, B.A., F.R.S.

2. *February* 24, 1915.—Dr. A. Smith Woodward, F.R.S., President, in the Chair.

The following communications were read:—

1. "The Ashgillian Succession in the Tract to the West of Coniston Lake." By John Edward Marr, Sc.D., F.R.S., F.G.S.

The author has studied in detail the succession of the Ashgillian strata in Ashgill Beck and the adjoining tract. In Ashgill Beck the following sequence was detected:—

VALENTIAN.

			Thickness in feet.
ASHGILLIAN	Upper	Ashgill Shales	about 50
	Middle	*Phacops mucronatus* beds	16
		Ash	16
		White Limestone	about 12
	Lower	*Phillipsinella* beds	7

CARADOCIAN.

An account of the lithological characters and lists of the fossil contents of the various divisions are given, and confirmatory sections from Coniston Village to Appletreeworth Beck are described. A comparison is made with the beds of the Cautley district, previously described by the author. Some fossils which have not yet been found in the Lower Ashgillian of the Cautley district occur in the beds of that division at Coniston.

From a study of the fossils of the Coniston tract and of other areas in Britain and the Continent, it would appear that a twofold division of the Ashgillian strata which is of more than local value may be made. The lower division is characterized by the abundance of *Phillipsinella parabola*, and the upper by the profusion of *Phacops mucronatus*.

2. "The Radio-active Methods of Determining Geological Time." By H. S. Shelton, B.Sc. (Communicated by Professor W. J. Sollas, Sc.D., F.R.S., F.G.S.)

The radio-active method of determining geological time, while of great interest, is not of such certainty as to be independent of confirmation from other lines of investigation. The various radio-active methods, helium ratios, lead ratios, and pleochroic haloes are severally examined, and the various sources of uncertainty, general and particular, are pointed out. The most important general cause of uncertainty is to be found in the fact that mechanical and chemical changes of composition in minerals are the rule rather than the exception; and, in instances where constancy of composition throughout long periods of geological time is asserted, the burden of proof lies with those who make the assumption. The attempt to assess exact or even approximate times by means of lead ratios is premature and entirely invalid. At the same time, the weight of the evidence is such as to render it exceedingly probable, so far as radio-active evidence goes, that geological time must be reckoned at least in hundreds of millions of years. There is a high degree of improbability that the errors in the radio-active methods should always be errors of overestimation. The next step in the investigation of

the time problem is to be found in a reversion to other lines of reasoning. The sea-salt methods, and those based on the thickness of the sedimentary rocks in particular, need careful reconsideration. Reference is made to a number of papers which show that the first of these is worthless, and the second based on a misapprehension of the nature of deposition. The argument from tidal retardation is still of value, as also is that from the evolution of carbonate of lime. To the author radio-active experiments come as a confirmation of views held on other grounds, but are not sufficiently important in themselves to be authoritative against the balance of the evidence derived from other lines of investigation.

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3. *March* 10, 1915.—Dr. A. Smith Woodward, F.R.S., President, in the Chair.

The following communications were read:—

1. "The Plants of the Late Glacial Deposits of the Lea Valley." By Clement Reid, F.R.S., F.L.S., V.P.G.S.

Large collections of plants from the Lea Valley deposits, already described, have been made by Mr. S. H. Warren, Mr. E. T. Newton, and Mr. Wrigley. The localities from which the plants were obtained are Angel Road, Hedge Lane, Ponders End, and Temple Mills. A list from Ponders End has already been given by Dr. Lewis; but the new collections include many unrecorded species, several of which have not previously been noted as British fossils. Although there are slight differences, the collections from all four localities are so similar as to leave no doubt that the deposits are contemporaneous. The whole assemblage points to a very cold climate, though perhaps not quite so cold as that indicated by the Arctic plants found at Hoxne, in Suffolk.

Among the more interesting novelties may be mentioned *Armeria arctica*, a species of thrift now confined to Arctic America, although it has also been recorded as a Pleistocene fossil from the continent of Europe by Dr. C. A. Weber. Leaves of *Salix lapponum* are also abundant, though this species does not seem to have been found fossil elsewhere. Some delicately-veined membranes, probably identical with the "petal-like objects" mentioned by Dr. Lewis, prove to be pods of the Alpine *Draba incana*. Other shorter forms are pods of a scurvy-grass, not yet satisfactorily determined.

The extinct forms are a new species of *Silene*, near to *S. noctiflora* but quite distinct, and a new *Linum* with large seeds. This latter apparently is closely allied to our cultivated flax (*L. usitatissimum*), of which the origin is unknown. It may be an ancestor of our common flax, but this latter is unknown far north, and will not grow with Arctic plants; the seeds of the two are perceptibly different. No large-seeded flax is now living in the Arctic regions.

2. "The Genus *Lonsdaleia* and *Dibunophyllum rugosum* (McCoy)." By Stanley Smith, B.A., M.Sc., F.G.S.

The present paper discusses the literature, structural characters and development, descent, classification, and distribution of the corals

constituting the genus *Lonsdaleia*; it includes also a description of *Dibunophyllum rugosum* (McCoy). The author's reasons for including a description of *D. rugosum* in the paper are, first, the fact that the species was originally described by McCoy as *Lonsdaleia rugosa*; and, secondly, that considerable confusion exists between it and the fasciculate forms of *Lonsdaleia*.

Lonsdaleia is a compound member of the Clisiophyllidæ, and occurs both as fasciculate and as massive colonies. The chief distinguishing features of the genus are the wide extrathecal area, large dissepiments, complex central column, and horizontal and widely-spaced tabulæ. *Lonsdaleia* is an Avonian or lower Carboniferous genus, especially abundant in the highest horizons of that series (D_2 and higher beds). The earliest example is *Lonsdaleia prænuntia*, from the *Syringothyris* zone (C).

A number of species and local forms have been recognized and are described.

II.—Geologists' Association.

March 26, 1915. The following paper was read:—

"On the Structure of the Eastern Part of the Lake District." By J. F. N. Green, B.A., F.G.S.

The paper relates to the Lower Palæozoic rocks of the country between Ullswater, Shap, and Stile End. The author summarizes the literature dealing with the area, and the divergent views as to its structure. A great tuff band has been traced all over the district, and the succession worked up and down from it. This succession proves to be identical with that near the Duddon Estuary, but the andesites are mainly concentrated at two definite horizons. By the aid of this succession it is shown that, as in the district previously investigated, the Borrowdale Volcanics rest conformably on the Skiddaw Slates, and are unconformably overlain by the Coniston Limestone Series, the junctions being unfaulted. The existence of separate basic and 'streaky' groups is not confirmed.

An important basal sandstone and conglomerate belonging to the Coniston Limestone Series, but hitherto confused with the underlying volcanics, is described. The folding is discussed, especially powerful overfolds in the neighbourhood of Haweswater. Faulting is considered, with special reference to the lag-fault hypothesis.

III.—Edinburgh Geological Society.

February 17, 1915.—Dr. R. Campbell, President, in the Chair.

1. "The Evolution of the Cartography of Prince Charles Foreland." By W. S. Bruce, LL.D., F.R.S.E., and John Mathieson, F.R.S.G.S.

The paper described the evolution of the cartography of Prince Charles Foreland from its discovery in 1598 to its complete survey in 1909.

2. "Preliminary Account of the Geology of Prince Charles Foreland." By R. M. Craig, M.A., B.Sc.

The island is a mountainous ridge 55 miles long and from 6 to 8 broad, lying parallel to the west coast of the mainland of Spitzbergen, from which it is separated by Foreland Sound. The backbone of the island is formed by the steeply folded members of the Hekla Hoek formation, which is considered to be of Silurian age. On the west coast, in the neighbourhood of Glen Mackenzie, a coarse conglomerate occurs, which rests unconformably upon the Hecla Hoek rocks, and has been derived from them. This conglomerate represents the base of a formation formerly more extensive, and may possibly be of Devonian age. On the east side a series of conglomerates, sandstones, and shales occur, forming a narrow strip along the coast from Vogel Hook to Point Napier. These beds have yielded plant remains which show that they are of Tertiary age.

3. "The Pre-Glacial Platform and Raised Beaches of Prince Charles Foreland." By the late Angus M'Ewen Peach, B.Sc. (Communicated by Dr. B. N. Peach, F.R.S.)

The paper dealt with the physical features and glaciation of Prince Charles Foreland and West Spitzbergen, the pre-Glacial platform of marine erosion, and the post-Glacial raised beaches.

IV.—Liverpool Geological Society.

February 9, 1915.—W. A. Whitehead, B.Sc., President, in the Chair.

The following papers were read :—

1. "On the Simultaneous Crystallization of Minerals and its Significance." By H. W. Greenwood.

The author had collected from Halkyn Mountain, North Wales, specimens of calcite containing abundant small spangles of towanite together with wurtzite and malachite, which by their orientation showed clearly that they had been deposited from solution simultaneously with the calcite. This occurrence seems to be identical with that at Joplin, Missouri, U.S.A., recorded in a recent number of the *American Journal of Science*.

2. "On the presence of Tourmaline in Eskdale (Cumberland) Granite." By T. A. Jones.

Tourmaline has been found recently by the author in fair quantity near joint planes in the granite at Beckfoot, Eskdale. The mineral occurs in tiny specks and irregular and sometimes radiating aggregates often exceeding one inch in diameter. The granite itself has here features which distinguish it in some degree from the general mass of the intrusion. While a coarse micropegmatitic structure is prevalent, a much finer intergrowth of quartz and felspar, closely resembling that of the neighbouring Buttermere and Ennerdale granophyre, is occasionally well exhibited. A detailed description of the microscopic characters of the tourmaline was given, and specimens and photomicrographs shown in illustration.

CORRESPONDENCE.

FLINTS FROM THE SUFFOLK BONE BED.

SIR,—On p. 64 of a recently published paper, entitled "Flints" (Cambridge Antiquarian Society's Communications, vol. xviii), Professor McKenny Hughes, F.R.S., in dealing with the question of the sub-Crag flint implements I have discovered, makes the following statement: "Mr. Reid Moir has long been trying to test this question by observation and experiment, and has arrived at the conclusion that nature does not produce the forms in question. I must, however, say that I have failed to arrive at the same conclusion, but find that identical forms are produced under shore conditions which must have been similar to those under which the Suffolk Bone Bed was laid down." The definite nature of this statement induced me to pay a visit to the Sedgwick Museum, Cambridge, to see and handle these flints, flaked under present-day shore conditions, which were said to be "identical" with the sub-Crag specimens—a typical series of which I took with me for comparison. The examination of Professor Hughes' beach specimens showed me at once that none of the forms labelled "Bec d'aigle" bore any real resemblance to the rostro-carinate specimens recovered from the Suffolk Bone Bed, and represented obviously naturally broken flints which no one familiar with the sub-Crag specimens could ever regard as in any way similar, and the same may with confidence be stated of the beach examples purporting to represent other sub-Crag forms. I have no wish to say any harsh thing about Professor Hughes, for whom I entertain a great respect and regard, but I think he has been unwittingly misleading by his misuse of the word "identical" in his paper, and that it is not quite fair to Sir Ray Lankester and me—and liable to fog the issue—to label specimens in the Sedgwick Museum "Bec d'aigle" which bear no real resemblance to the sub-Crag rostro-carinate specimens.

J. REID MOIR.

12 ST. EDMUND'S ROAD,
IPSWICH.

GUIDE TO THE FOSSIL REMAINS OF MAN IN THE BRITISH MUSEUM.[1]

SIR,—I have read with much interest the review of the *Guide to the Fossil Remains of Man* in the British Museum, published in the GEOLOGICAL MAGAZINE. Would it not be possible in the second edition to allow the Neanderthal man (as shown in fig. 12) a *scapula*? Such an omission is sure to lead to some silly mistakes on the part of the general public, for whom I presume this guide is written.

R. S. NEWALL.

FISHERTON DE LA MERE HOUSE,
WYLYE, WILTS.
March 15, 1915.

[1] See GEOL. MAG. for March, 1915, p. 129.

OBITUARY.

PROF. JAMES GEIKIE, LL.D., D.C.L., F.R.S. L. & E., F.G.S.[1]

BORN AUGUST 23, 1839. DIED MARCH 1, 1915.

By the death of Professor James Geikie on March 1 geology in Scotland has lost its most prominent representative. He had been in failing health for some months, but the end was sudden and unexpected. In June, 1914, he had resigned his Chair in Edinburgh University, but as President of the Royal Society of Edinburgh, and Honorary Editor of the *Scottish Geographical Magazine*, he had much congenial work with which to occupy his time. His funeral took place on March 5 and was attended by a large and distinguished assembly, including representatives of the University, the Royal Society of Edinburgh, the Geological Survey, the Scottish Geographical Society, and many other scientific bodies. A full sketch of his scientific work and career appeared in the GEOLOGICAL MAGAZINE for June, 1913, pp. 241–8. Since that date he had delivered the Munro Lectures in Archæology at Edinburgh University, which he subsequently published as a book entitled *The Antiquity of Man in Europe* (Edinburgh, 1914). The previous year had seen the publication of his volume on *Mountains, their Origin, Growth, and Decay*. To the last he continued his earnest researches in physical and historical geology, and by his genial personality, wide sympathies, and inspiring example he was a powerful influence for research in the sciences of geology and geography, to which he had devoted his life.

J. S. F.

MISCELLANEOUS.

BERNARD H. WOODWARD, F.G.S., For. Corr. Z. S. Lond., Director of the Natural History Museum and Art Gallery, Perth, Western Australia.—We regret to announce the retirement of Mr. B. H. Woodward, after some twenty years, from the post of Director. Since his appointment the New Museum and Art Gallery have been erected, and the excellent arrangement of the entire collections is the result of his extensive knowledge, sound judgment, and untiring energy, the valuable art section in particular being entirely due to his initiative. His published reports on the fossil mammalian remains collected from the Mammoth cave of Western Australia, and upon the new and interesting zoological collections made in the colony, have added largely to the value and importance of this section of the Museum.

ERRATUM.—The Editor regrets that on Plate IV (*Schlotheimia Greenoughi*), in March Number, GEOL. MAG., some lines (viz. the incorrectly restored outline of the inner whorls) were erroneously added to the original drawing and not deleted before the proof was sent to press.

[1] For Portrait and Life see GEOL. MAG., June, 1913, pp. 241–8, Pl. IX.